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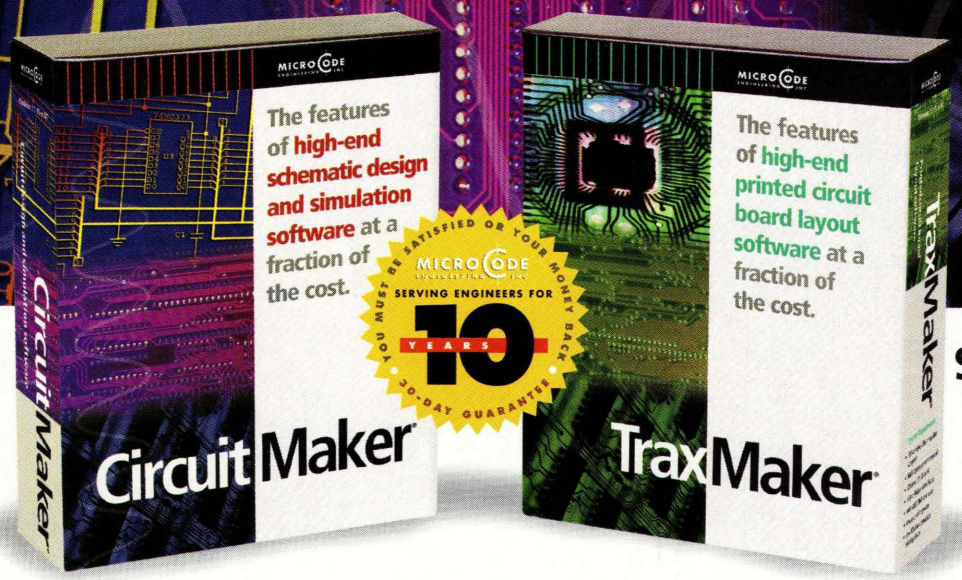
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Electronics NOW

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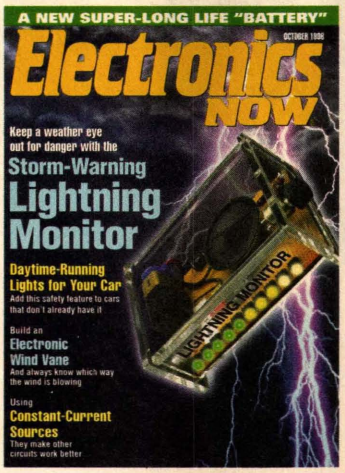
Even in normal times, everyone always talks about the weather. But this year has been something else again. Between El Niño, La Niña, killer tsunamis, increased tornado activity, a predicted very active hurricane season, paralyzing ice storms, scorching heat waves, droughts, and more, it seems like no one is talking about anything else — and, at least this month, that includes us! Our cover story this month is a circuit that can give you a few precious extra minutes to prepare in the face of an approaching storm. It monitors the airwaves for the telltale RF crackle caused by dangerous lightning and signals that trouble is on the way when it detects it. — *Kenton Chun*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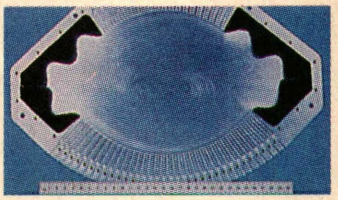

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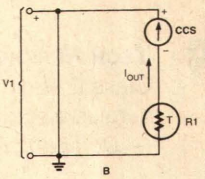

They're often overlooked, but constant-current circuits are easy to use, and make other circuits work better. — *Joseph J. Carr*

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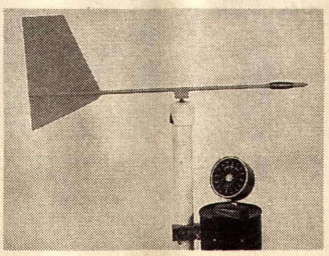

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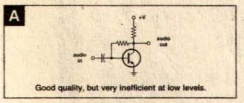

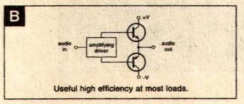

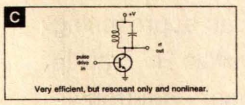

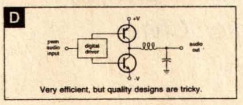

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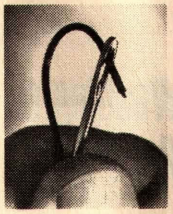

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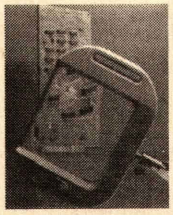

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EDITORIAL

NESDA Goes To Washington (A Guest Editorial)

NESDA (the National Electronics Service Dealers Association) has always taken its responsibilities very seriously—representing the professional service dealer industry to manufacturers, distributors, educational institutions, other business organizations, and frequently even to state and federal governments. But this past June NESDA took its representation to a new level. It sent several members of its leadership to Washington, D.C. to lobby Congress on a bill that could have a serious impact on the professional service industry. This action also extends NESDA's representation to a new constituency—those customers who depend upon NESDA members to keep their consumer-electronics equipment working.

The bill in question is known in the House of Representatives as H.R. 2281. It implements an international copyright treaty. Why should professional service dealers care about an international treaty? We had better care about it, because in implementing the treaty to extend copyright protection to the creators of copyrighted works like movies, music, and other "intellectual property," H.R. 2281 allows "technological protection measures" that could affect the functions of next-generation VCRs, computers, and other recording products, and our ability to service them.

We must make sure that professional servicers can make changes to new products to guarantee their "playability," so that when consumers use these products in a lawful way, they will function the way consumers expect. If some "technological protection measure" interferes with the proper authorized viewing or recording of a copyrighted work, we must make sure that the professional servicer can address the problem without the servicer or the consumer being branded a lawbreaker.

Next-generation home electronics products in the digital age are going to be expensive, high-end equipment that consumers are going to want serviced to protect their investment. They will not be the "throwaway" products that are being sold today.

NESDA President Randy Whitehead CSM, Executive Director Clyde Nabors, and I met with our personal representatives in Congress, but we also met with representatives of the leadership of Congress—Majority Leader Dick Armey, Majority Whip Tom Delay, and others. All we met seemed pleased that we had brought the professional service dealers' point of view on H.R. 2281 to Congress. They expressed their gratitude that we were bringing to them the expertise and knowledge of an industry that apparently had been "written off" by the authors of the bill. They asked us for specific suggestions on how the bill needed to be changed in order to protect the professional service-dealers industry and the best interests of our customers. And we are providing those suggestions.

At this writing, in late June of 1998, the U.S. Senate's version of the treaty implementation legislation has been passed and the bill has been approved by one House committee. The House Commerce Committee is looking at it now and trying to assess its impact on American consumers and businesses, particularly the small-business community. We are going to make sure that the Commerce Committee has the information it needs to write a balanced bill.

So this is where NESDA chose to make its stand—to make the voices of professional service dealers and our customers heard where it will count the most: to bring the expertise and knowledge of our industry to the Members of Congress so that they can legislate based on expert information. This was the first time NEDSA actually walked the halls of Congress. But with the technology we deal with daily changing so rapidly and with Congress' hunger for expert knowledge to keep up with those changes, I'll bet it won't be the last time.

Susan Frick
Vice President
NESDA

Q & A

READERS' QUESTIONS, EDITORS' ANSWERS
CONDUCTED BY MICHAEL A. COVINGTON, N4TMI

Frequency-Counter Flub

In June, we recommended that a reader build the 1-GHz frequency counter featured in our December 1990 issue. Joseph W. Baldwin wrote to advise us that due to a faulty front-end design, that particular counter won't actually work above 25 MHz—a fact that was addressed in a correction that was published in February, 1991.

We apologize most humbly; that project and its correction were published before your present columnist came on board, and the editorial department didn't catch the mistake in the June column. Apart from the frequency limitation, the counter works well.

If you've built this counter, you can probably improve it a bit by changing the 7490 and CD4017 (IC1 and IC3) to a 74AC190 (making appropriate pin connection changes) and 74HC4017 respectively. Even so, that will get you to 100 MHz at most. For proven 1-GHz counter circuits, see the *ARRL Handbook for Radio Amateurs.*

Watt's That?

In the July, 1998 issue, Fig. 1, page 8, we forgot to specify the wattage of the fluorescent bulb. It is 4 watts.

LED Light Chaser

Q *I'd like to build an LED chaser for my car. I've drawn a schematic using a motor-driven rotary switch. Is there a simpler way?—C. B., Boiling Springs, PA*

A A chaser, for those who don't know, is a circuit that makes lights turn on one after another, over and over, so that a spot of light seems to be moving rapidly along the string of lights. LED chasers are popular automotive decorations; some people wrap them around license plates or stretch them out inside the rear window.

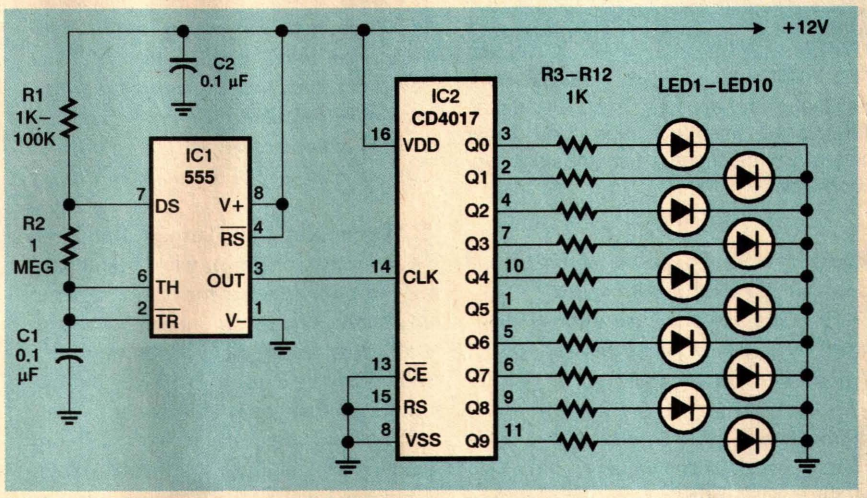

FIG. 1—IN THIS SOLID-STATE LED light chaser, speed is set by R2 and C1. As long as it is much smaller than R2, the value of R1 is not critical.

Motor-driven rotary switches are exactly how chasers were built in the days before digital ICs. Nowadays you can do the whole thing digitally, and Fig. 1 shows how.

The 555 IC (which can be an NE555, TLC555, 7555, or equivalent) generates pulses about seven or eight times per second. The CD4017 counts these pulses and activates its ten outputs one at a time, in succession. Each output drives an LED. Note the rather arbitrary pin numbering; the pins of the IC are not in the same sequence as the flashing of the LEDs.

The speed of the "chase" is controlled by R2 and C1; larger resistors and/or capacitors make it slower. You can use a 1-megohm potentiometer for R2 to make the speed adjustable. Resistor R1 provides a charging path for the capacitor and has little effect on frequency as long as it's substantially smaller than R2. Capacitor C2 protects the ICs against voltage spikes—a good idea in any digital circuit, especially an automotive one. For testing or for non-automotive applications, you can power the circuit from a 9-volt battery.

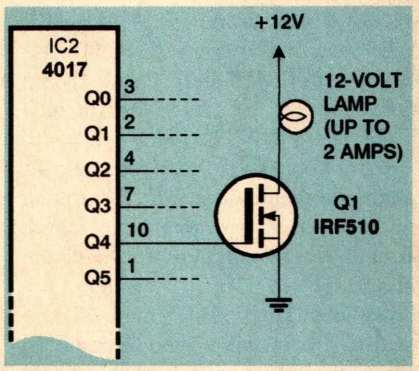

FIG. 2—IF YOU NEED to have your light chaser drive high-current bulbs, use this switching-transistor interface.

If you want to drive brighter lights instead of LEDs, use switching transistors as shown in Fig. 2.

Surge Protectors

Q *Your December 1992 issue (page 45) describes a modem/fax protector consisting of two gas surge arrestors and four 1N5386B (180-volt, 5-watt) Zener diodes (see Fig. 3).*

I haven't been able to locate the diodes.

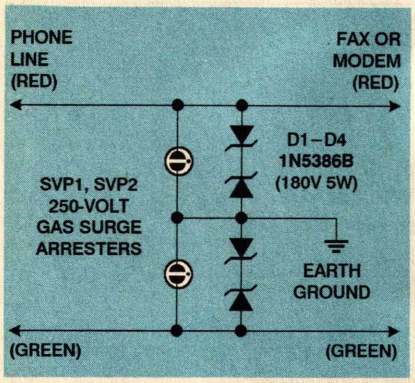

FIG. 3—THIS SURGE PROTECTOR, which originally appeared in our December, 1992 issue, uses gas tubes and Zener diodes to protect against surges on a telephone line.

Would varistors be adequate substitutes, and what voltage rating do you suggest?

Also, what do "protection-working" indicators for varistors consist of?—W. A. E., Toronto, Ontario, Canada

A You could use varistors with a 180-volt breakdown voltage, but they might not be entirely equivalent because a Zener is able to dissipate power continuously and a varistor is not. You can get 1N5386B's from Digi-Key (701 Brooks Ave. S., Thief River Falls, MN 56701; Web: www.digikey.com; Tel: 800-344-4539, or 218-681-3380). Other diodes equivalent to the 1N5386B include ECG5164A and NTE5164A.

As for your second question, we took apart a power-line surge protector to find out; Fig. 4 shows what we found. Naturally, protection indicator lights can only be powered by power lines, not phone lines. The one we examined consisted of a neon pilot lamp assembly in series with a large fuse (8 amps, but 1 amp would be a more conservative choice). The idea is that a lightning strike powerful enough to destroy the varistors would probably also blow the fuse. Note that the light does *not* detect gradual deterioration of the varistors from multiple mild surges, so it doesn't *prove* that the varistors are good.

MEET YOUR COLUMNIST

Since mid-1995, the Q&A column has been conducted by Michael Covington, and beginning this month, his name is on it. By day, Dr. Covington is a research scientist at the University of Georgia's Artificial Intelligence Center; by night he does writing and consulting. "Electronics used to be my hobby, but by now it's definitely part of my profession," explains Covington, who is a senior member of the IEEE, a ham-radio enthusiast (N4TMI), an amateur astronomer, and the author of more than 200 magazine articles and several books.

VR For VW

Q *I want to replace the electromechanical voltage regulator in my car, a 1967 Volkswagen Beetle, with a solid-state device. I've found numerous schematics for voltage regulators, but all of them are for cars that have an alternator. My car has a generator. Can you help?—J. B. S., Lubbock, TX*

A We consulted a real expert, Bob Pease (www.nsc.com/rap), who, besides being a top IC designer for National Semiconductor, is also an authority on late-1960s VW Beetles. He is not aware of a solid-state regulator for your car and recommends that you stick with the existing technology; after all, it works. If any readers have built a solid-state voltage regulator for a VW Beetle, we'd like to hear from them.

Fleet Of CD Changers

Q *I'm planning on opening a radio station and will be purchasing 28 Sony 200-CD changers. My problem is, how can I control all 28 changers from a single computer? Sony makes a control unit, but I don't know if it will daisy-chain to control more than one changer.—B. K., Gainesville, MO*

A For a purchase of that size, Sony should be able to give you some engineering assistance; contact them with your questions. If they don't have the product you need, they probably ought to develop it; yours can't be the only radio station that needs this capability. Contact Sony by e-mail at contact@sel.sony.com or by telephone at 941-768-7669. (Oddly, they don't give a mailing address on their web page.) Or you may want to hire an electronics consultant to design and build what's needed—but if you take that option, be prepared to spend thousands of dollars.

Cold Hands

Q *I am a high school student in a marching band. When we perform in the dead of winter, my hands freeze, almost to the point of frostbite. I was wondering if there was some kind of battery-powered electronic heating device that would keep my hands warm but would not alter the appearance of skin-tight white gloves.—B. H., Waukesha, WI*

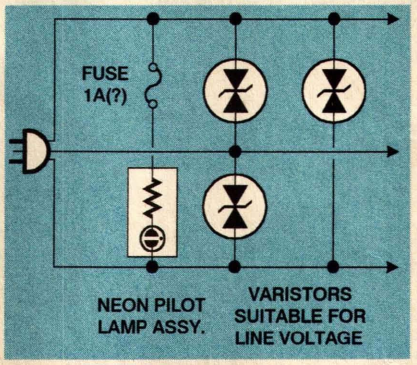

FIG. 4—HERE'S THE "protection-working" circuit inside one surge protector. If the light goes out, it is a safe bet that the varistors have also failed, but the light being on is no guarantee that protection is still in place.

A Let's do the math. To warm your hands to a useful extent, your device would have to dissipate something like three watts of power. (Watts measure heat or any other form of energy, not just electricity.) Recall that watts = volts × amps. If it is powered by a 1.5-volt battery, your device would therefore consume 2 amps and would need a resistance of 0.75 ohm.

The idea might work if you can conceal a hefty battery pack elsewhere on your person. Try two D-cells in parallel, and make the heating element out of a piece of nichrome wire whose total resistance is 0.75 ohm (measure it), wrapped in some type of protective covering (perhaps heat-shrink tubing). If the wire gets too hot, use a longer wire to achieve a higher resistance. Be aware that a partial break in the nichrome could create a localized hot spot.

Testing Telephones

Q *I have several telephones I'd like to try to repair, but I do not want to hook them to my telephone line during the testing process. Do you have a circuit for a simple telephone test set that would supply power for the telephones under test and perhaps a speaker that would allow testing of the talk circuit?—R. G. Z., Finksburg, MD*

A How about a 9-volt battery? Except for the ringers, you can test a telephone by connecting it to another tele-

HOW TO GET INFORMATION ABOUT ELECTRONICS

On the Internet: See our Web site at http://www.gernsback.com for information and files relating to our magazines (**Electronics Now** and **Popular Electronics**) and links to other useful sites.

To discuss electronics with your fellow enthusiasts, visit the newsgroups sci.electronics.repair, sci.electronics.components, sci.electronics.design, and rec.radio.amateur.homebrew. "For sale" messages are permitted only in rec.radio.swap and misc.industry.electronics.marketplace.

Many electronic component manufacturers have Web pages; see the directory at http://www.hitex.com/chipdir/, or try addresses such as http://www.ti.com and http://www.motorola.com (substituting any company's name or abbreviation as appropriate). Many IC data sheets can be viewed online. Extensive information about how to repair consumer electronic devices and computers can be found at www.repairfaq.org.

Books: Several good introductory electronics books are available at RadioShack, including one on building power supplies.

An excellent general electronics textbook is *The Art of Electronics*, by Paul Horowitz and Winfield Hill, available from the publisher (Cambridge University Press, 1-800-872-7423) or on special order through any bookstore. Its 1125 pages are full of information on how to build working circuits, with a minimum of mathematics.

Also indispensable is *The ARRL Handbook for Radio Amateurs*, comprising 1000 pages of theory, radio circuits, and ready-to-build projects, available from the American Radio Relay League, Newington, CT 06111, and from ham-radio equipment dealers.

Copies of past articles: Copies of past articles in **Electronics Now** and **Popular Electronics** (post 1993 only) are available from our Claggk, Inc., Reprint Department, P.O Box 4099, Farmingdale, NY 11735; Tel: 516-293-3751.

Electronics Now and many other magazines are indexed in the *Reader's Guide to Periodical Literature*, available at your public library. Copies of articles in other magazines can be obtained through your public library's interlibrary loan service; expect to pay about 30 cents a page.

Service manuals: Manuals for radios, TVs, VCRs, audio equipment, and some computers are available from Howard W. Sams & Co., Indianapolis, IN 46214 (1-800-428-7267). The free Sams catalog also lists addresses of manufacturers and parts dealers. Even if an item isn't listed in the catalog, it pays to call Sams; they may have a schematic on file which they can copy for you.

Manuals for older test equipment and ham radio gear are available from Hi Manuals, PO Box 802, Council Bluffs, IA 51502, and Manuals Plus, PO Box 549, Tooele, UT 84074.

Replacement semiconductors: Replacement transistors, ICs, and other semiconductors, marketed by Philips ECG, NTE, and Thomson (SK), are available through most parts dealers (including RadioShack on special order). The ECG, NTE, and SK lines contain a few hundred parts that substitute for many thousands of others; a directory (supplied as a large book and on diskette) tells you which one to use. NTE numbers usually match ECG; SK numbers are different.

Remember that the "2S" in a Japanese type number is usually omitted; a transistor marked D945 is actually a 2SD945.

Hamfests (swap meets) and local organizations: These can be located by writing to the American Radio Relay League, Newington, CT 06111; (http://www.arrl.org). A hamfest is an excellent place to pick up used test equipment, older parts, and other items at bargain prices, as well as to meet your fellow electronics enthusiasts—both amateur and professional.

phone and a 9-volt battery, all in series. With this hookup the telephones should be able to talk to each other and should produce tones when you press the buttons. You can even test a telephone by itself by connecting it to a 9-volt battery; you should be able to hear your own voice in the earpiece.

The green and red wires are normally positive and negative respectively (the only place in all of electronics where red denotes negative), but a telephone should work with either polarity. Once everything else is working, you can test the ringer by connecting the telephone to a working line and having someone call it.

Q&A By E-Mail

Q *Please put your e-mail address on your Q&A column.—E. M. (via e-mail) and numerous other readers.*

A There are several reasons we've been hesitant to invite Q&A submissions by e-mail. It would lead people to expect instant replies, which we can't give; each question has to wait its turn, not all questions are selected for publication, and because we're a monthly magazine, we have to maintain a few weeks' backlog. Also, e-mail would discourage people from enclosing the all-important circuit diagram. This is a situation in which old-fashioned paper correspondence actually works better. When necessary, you can contact us electronically via our web site (www.gernsback.com). If time is of the essence, you can sometimes get very quick answers to your electronics questions in the sci.electronics newsgroups (discussion forums) on the Internet and our own electronics forums on our Web site

Jukebox Help Request

Q *I have a Seeburg model HF100R jukebox dating from around 1954 and need to get it repaired. Where can I obtain schematics, troubleshooting advice, or the name of someone in my area that can repair it?—Steve Tambeau, 1519 Watson Street, Scranton, PA 18504*

A According to ads on the Internet, vintage jukebox manuals, including the one you require, are available from Bumper Action Amusements, 562-566 City Rd., South Melbourne 3205, Victoria, Australia; Web: www.bumper.com.au; Fax (as dialed from the USA): 011-61-3-9696-6777. (They accept U.S. Visa and MasterCard.)

You might also contact '59 Jukeboxes, Inc., 9613 Harford Road, Suite 359, Baltimore, MD 21234; Tel: 410-661-7588; e-mail: jukebox@sitestar.com. They stock parts for later-model (post-1959) Seeburg jukeboxes and can probably give you some help. And we're publishing your name and address so other people can contact you directly.

Intermittent TV Tip

Q *In your November 1997 issue a reader asked about a 1978 Zenith TV that had intermittent loss of picture upon turn-on. I had one in my shop that did something similar, and the problem turned out to be a poor connection in the socket where Zenith had installed the video amplifier transistors. My solution was to solder the transistors in.—Roger Doering, Camp Verde, AZ*

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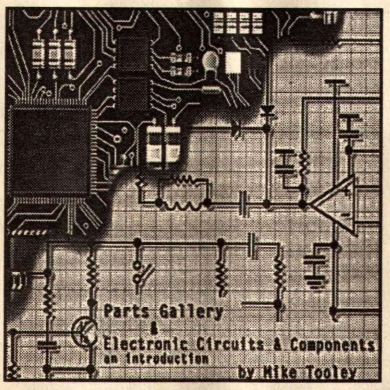

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A Thanks for the tip. Intermittent video can be caused by a loose connection anywhere along the signal path, and transistor sockets are a notorious source of problems. So are the connectors that link separate circuit boards.

As you note in your letter, the problem could have many other causes, and working on a TV is dangerous due to high voltages; readers who are not familiar with TV servicing or don't have appropriate equipment should of course use the services of a repair shop.

Air Cleaner Power Supplies

Q *In the July 1998 issue a reader asked about building a replacement power supply for his electronic air cleaner. I tried it, but the diodes did not survive very long even though they were properly rated. You can buy a replacement power supply from Trion, Inc., 101 McNeill Road, Sanford, NC 27331; Tel: 919-775-2201. This company made air cleaners for Sears and others.—Earl Morris, via e-mail*

A Thanks for the tip! We called Trion and they said that they supply parts for some models of other brands, but not all. For a Sears air cleaner, for example, they recommend trying Sears first.

Writing to Q&A

As always, we welcome your questions. The most interesting ones are answered in print. Please be sure to include plenty of background information (we'll shorten your letter for publication) and give your full name and address (we'll only print your initials). *If you are asking about a circuit, please include a complete diagram.* Due to the volume of mail, we regret that we cannot give personal replies. EN

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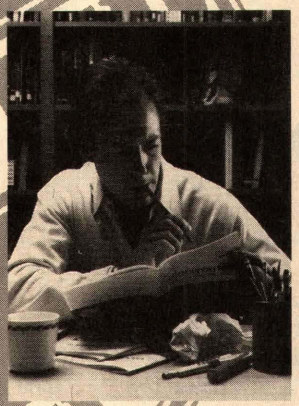

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LETTERS

SEND YOUR COMMENTS TO THE EDITORS OF ELECTRONICS NOW MAGAZINE

Silly Shunts

A few errors crept into my article "Make Your Own Shunts" in the August 1998 issue. First, in the third paragraph, third column, on page 51, reference is made to watching the meter "...until the analog meter's needle moves to a full-scale reading." Actually, the meter's reading is not significant. The only thing to be concerned about here is the needle not being pinned against either stop, which could damage the meter itself.

The next problem involves the equations in the center column on page 52. The units there should obviously be ohms, not volts.

Finally, near the bottom of the second column on page 52, reference is made to winding the coils over "an insulated screwdriver handle or something similar such as a non-conductive wood dowel." Actually, the conductivity of the form is not important, since it is only used to wind the wire into a coil and then removed.

DEAN F. POETH, II, Ph.D.

Troubleshooting Tips

To anyone who has built my "No-Parts PIC Programmer" in the September 1998 issue and has had trouble with it, here are some simple checks:

1. Check my Web site (www.mindspring.com/~covington/michael). Updates, if needed, will be posted there.
2. Measure the +5V and +12V supply voltages. The 12-volt supply must be between 12.0 and 14.0 volts. Some "12-volt" power supplies are considerably outside that range.
3. Use a fresh or tested PIC. Be sure to protect the PIC from static electricity when you handle it.
4. If your PC BIOS provides different settings for your parallel port, try all of them. NOPPP should work with any setting (compatible, bi-directional, ECP, or EPP), but choose "compatible" if you have any doubts.
5. Finally, if you still can't get NOPPP to work, try it on another PC, if possible.

I am interested in helping people troubleshoot this project. If you've built NOPPP and can't get it working, write to me.

MICHAEL A. COVINGTON
Covington Innovations
385 St. George Drive
Athens, GA 30606

Editorial Approval

I have never written to the Editor of **Electronics Now** before, but I'd like to let you know how much this subscriber agrees with you and enjoyed your courageous editorial in the August issue. I use the word courageous since it goes against all of the trendy Microsoft bashing currently seen in the press.

My wife studied many hours for the Microsoft certification exam, which she's passed. This entitles her to use the Microsoft logo on her business cards and on our Web page. This also gives Microsoft bashers an excuse to flame her for using the logo of the "evil empire of Redmond, WA."

ERICH KERN
via e-mail

...and Disapproval

Knock, Knock....Hello??? Have you been paying attention to the objections to Microsoft and its built-in programs? The issue is this: once you have complete control of the desktop, some controls must be in place in order to provide a choice. Even the Defense Department realizes this as they like to have at least two suppliers for a product.

No one is saying that Microsoft should not be able to include its browser, even though it's a captive audience. What they are really saying is that the playing field should be level. No application should be build into an operating system for many reasons. So, provide "hooks" into your system so your browser (Microsoft's) and anyone else's browser will work on the desktop. Don't deliberately build it so that it cannot be removed, and then plead that everyone is not being "fair" to your "unfair" business actions.

Personally, I am sick of hearing about it.

By the way, what will you say next year when Microsoft issues the next version with a built-in speadsheet, and the year after that with a built-in word processor? Of course, these products will not be able to be removed without damaging the operating system. Will we tolerate the lies then as we did when we listened to such things as "full 32-bit system (Windows 95)," etc.?

RICHARD GOEKEN
via e-mail

Write To:
Letters,
Electronics Now Magazine,
500 Bi-County Blvd.,
Farmingdale, NY 11735

Due to the volume of mail we receive, not all letters can be answered personally. All letters are subject to editing for clarity and length.

Worth the Price

I had just completed writing *Magnets and Magnetic Sensor Projects*, a new RadioShack project book, when the mailman dropped off the July issue of **Electronics Now** with Joseph Carr's article on magnetic sensors. It appears that the versatile Joe Carr is as adept at discussing fluxgate magnetometers as he is at describing antennas, radio circuits, solar effects on the atmosphere, medical, electronic, and a host of other topics. Thanks for providing us readers with Joe Carr's contributions. His articles alone are well worth the price of a subscription.

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More "Who Am I?"

I am a 61-year-old retired electronics engineer/technician. I attended a vocational school in the early 50s and was a radio/TV repairman during that time. After graduation, I was in the U.S. Navy for six years working as an electronics technician. I was discharged in 1962 and went to work for the Naval Research Laboratory in Washington DC and started college at the same time. I graduated with a BSET degree in 1967. My nine years at NRL were spent in the design and development of meteorological equipment. In 1971, I went to work for ESSA (which became NOAA) in Miami, where I continued to work until I retired. My work at NOAA was mostly the design, development, and deployment of underwater acoustic systems.

Electronics has always been my hobby along with powerboat racing and Corvette cars. My electronic interests include antique radio and experimenting with many different circuits and applications. I am not just interested in the technology but also the history and the people involved.

I think there are enough magazines for and about computers. Please do not add **Electronics Now** to the list. If you can add articles about the application of computers such as using PCs to act as test or measurement instruments, this would be useful. Everyone has or can obtain an older PC that can be the center of some measurement or test instrument or system. I know that there are plenty of commercial programs and hardware that already do data acquisition and display, but most are too costly for the hobbyist. However, some simpler and application-specific system could be designed that would not be as general or expensive.

CHARLES LAUTER
Miami, FL

I have been subscribing to **Electronics Now** for about 4 or 5 years. This was also how long I have been interested in the electronics hobby. I am a computer programmer by trade, currently working with a group of EEs on designing test equipment. At work, I view hardware as an item to blame when my software doesn't work.

My major focus on electronics involves hobby work that I'm doing with 8051 processors and various smaller projects. I read your magazine to help me design and build my projects better. The articles that interest me least are single-purpose build projects with hard-to-find components. (You can determine if a component is hard to find if none of your advertisers carry it.) I also find articles that center on a microprocessor but do not provide source code to be almost worthless. Yeah, the source code doesn't help you build the project, but without an E(E)PROM programmer, the object code doesn't help either. Besides, someone may have a BASIC microprocessor that can be modified to fit the project and then the source code would be handy. Also, some of us just like to read source code to get ideas.

I would like to see more basic articles, such as the current one on magnetic sensors, and the one a while back on transistors. I would also like articles on basic board design. I notice almost all the projects use PC boards and there is no mention of why not use wirewrap, or any discussion on the limitations of different techniques. I would also like articles on basic equipment, such as O-scopes and other fairly common devices. Construction articles should also discuss the whys, such as why use a TTL component, instead of an HMOS or CMOS. In short, these are sort of an expansion of what is in Horowitz and Hill's *Art of Electronics*.

I find Sam Goldwasser's articles very good. We all have a few broken appliances, and my wife certainly would be impressed if I could fix one. Don Lancaster's recent article on temperature sensors was interesting. You can tell him that we don't need an article on writing a real-time operating system in Postscript though. In fact, I don't think you really need articles on software unless there is enough hardware components to justify it. There are plenty of magazines that cover software.

Although I am currently not into RF, I would like to see articles on RF. After all, you used to be **Radio-Electronics**. I would also like to see articles on motor control and motors in general. (A good series would be to design a garage door opener—it has everything, RF, microprocessor, and a big motor.) In short, I am looking for articles that inform me on how to build my next project better.

The new Prototype section may be worth it, but why you included an article on anti-virus space research beats me. I like your advertising section. It is a good resource for parts.

BOB ENGEL
via e-mail

I enjoy the magazine! I especially enjoy the experimenter/kit ideas. Many times I am not interested in building the project, but I am interested in learning more. I would like to see between three and four projects in each month's edition.

I am an electrical engineer and have in the past built or repaired electronics items. I always enjoy these articles. I am also a Radio Amateur, N7RGW. I subscribe to other magazines such as *QST*. I also subscribe to computer magazines. I like the niche that you are filling: a combination of computer, electronics, and radio. I would hate to see you make a drastic change in what you are doing, but I understand that fewer and fewer people seem to be dealing with the hardware issues of electronics. I teach engineers as part of my job, and I am amazed at how many new college graduates do not know electronic components or instruments, such as oscilloscopes.

I am enjoying the series about how to repair a CD player. I enjoy learning about the problems and solutions. I also enjoy the question and answers column. One more thing, I really enjoy the advertisement section and the way that you have it organized. I like it all in one place, and I always review it.

LARRY LOVELL
via e-mail

What a timely question. I was just asking myself that question—What do I want? Who am I? I am a 36-year-old male, married, and father of three young boys. My background in electronics is very limited, but my interest in it is not. I became interested in electronics when I was forced to look for a possible new career. The factory where I am presently employed has warned us of a possible closure. I began taking night courses at our local college; three years later and four courses short of a college diploma (plus a two-year subscription to your magazine) I find myself questioning how I can use this newfound knowledge.

I have found your magazine to be somewhat advanced for someone with limited experience in the trade such as myself. However, I find Tech Musings and Prototype very informative. **Electronics Now** is a fine magazine. My only request is to perhaps have an occasional project that a person with limited experience can try and learn with.

SAM STAGNO
via e-mail

EQUIPMENT REPORT

TEKTRONIX TX-3 DIGITAL MULTIMETER

Tektronix outdoes itself once again with the TX-DMM family of hand-held digital multimeters.

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A company that is renowned for producing products that are top-notch in quality and performance faces a unique problem: When it comes time to freshen up a product line, it takes a tremendous amount of effort to outdo the last top model. That is certainly true of Tektronix DMMs, which have always been among the best in the world. Amazingly enough, however, Tektronix' new TX-DMM family of digital multimeters outperforms the last generation, but without sacrificing one bit of their legendary ruggedness.

Let's face it: Tektronix DMMs are intended for professional use, where long-term accuracy, durability, and convenience are more important than initial cost. Auto mechanics use sockets that cost $5 apiece, are guaranteed for life, and never break, rather than the imported socket sets that contain hundreds of tools for $19.99. For the same reasons an electronics professional will usually spend hundreds of dollars on one quality DMM rather than buy $50 units every few months. A DMM is a technician's most important tool, and one can't afford to be out in the field with a DMM that might fail. That said, however, the pricing on these high-end units is not out of line with that of similar units from other manufacturers, and is not out of reach for a dedicated hobbyist who is serious about his or her efforts.

The TX-DMM series of DMMs consists of two models: the TX-1 and the TX-3. Made in the USA, the TX-1 is priced at $275 and the TX-3 at $325. We examined the TX-3, which adds built-in temperature measuring, even greater accuracy, and other advanced functions to the TX-1's feature set.

Tektronix' new TX-3 is loaded with convenience features that make it easy to live with day in, day out. The rubber holster's built-in stand can be positioned in the standard, standing position, horizontally so the meter can grab onto a bar or rail, or vertically so that the meter can hang from a nail or hook. The probes store safely and conveniently in the back of the holster. The probes are of the best quality we've seen on a DMM, and they come with "why didn't I think of that" protective caps for the probe tips and plugs.

The TX-3 has a lighted display with adjustable auto shut-off time for both the light and the meter. Auto shut-off can be overridden so that the light and/or the meter will remain on indefinitely. The TX-3 is powered by two AA batteries that are accessed by removing the meter's water-resistant, slide-off bottom cap. The batteries should last 100 hours with the backlight off. Calibration is unaffected when changing the batteries because the meter does not have to be unsealed to change them. Speaking of calibration, the TX-3 will provide an electronic readout of the last calibration date and comes with a traceable calibration certificate.

Considering its features, the TX-3 is compact, measuring about 1.5 × 3.5 × 5.25 inches. It weighs 13.5 ounces bare and 19 ounces in its holster. It feels heavy and ruggedly built, with the rotary switch clicking sharply with each step. The true rms meter is extremely accurate and category III certified to 1000 volts AC. There's even an option to connect the TX-3 to a PC for data-acquisition and logging, though we did not test that capability.

TX-3 Features

The TX-3's dual display lets you see two measurements at once, for example the amplitude and frequency of a current or voltage. The meter allows temperature measurements from -50 to +980 degrees C with the included temperature probe, so there's no need for any extra equipment. A measurement-hold function freezes measurements that might be made in awkward viewing situations, and there are 30 memory locations to store measurements for later scrutiny. Memory is saved even when power is turned off or if the batteries are changed. A time-stamped min/max recorder catches transients that might otherwise be missed and indicates when they occurred.

The TX-3 has a 50,000 count display along with a bargraph readout. It measures AC and DC voltage, AC + DC (rms) voltage, AC and DC current, resistance, frequency, diodes and capacitors, continuity, duty factor, and temperature. There's also a delta mode. All functions have an indicator on one of the most elaborate displays we've ever seen. The TX-3's display has two modes with either 4-$^4/_5$ or 3-$^4/_5$ digits, and either 50,000 counts with 1 reading per second or 5000 counts with 4 readings per second. A 20-segment bargraph is updated 20 times per second.

The TX-3's maximum input voltage is 1000 volts AC or DC and is accurate to ±0.05 %. The maximum current input is 10 amps for up to three minutes or 15 amps for 30 seconds. The meter can measure resistance from 0.01 ohm to 50 megohms, capacitance from 5 nF to 50 µF, and frequency up to 1 megahertz.

(Continued on page 18)

BY JEFF HOLTZMAN

Celestial Reasoning, More on PRNGS, And A New Long-Term Project

IT'S CRYSTAL BALL TIME. THE RECENT ALIGNMENT OF CERTAIN CELESTIAL BODIES HAS ENABLED THE FOLLOWING TRUTHS TO REVEAL THEMSELVES TO YOURS TRULY. I'VE DECIDED TO PASS THEM ON ROYALTY FREE.

PC performance is topping out. For the first time ever, a PC bought in 1998 may last a decade or more, barring any major breakthroughs, such as RAM that can run at CPU speeds or whose density increases by several orders of magnitude, with a corresponding decrease in price.

A hot computer a decade ago was a 25-MHz 386; most people still used 286s, and there were still tons of XTs in use. Will today's leading-edge 400-MHz Pentium IIs look as dated a decade from now as the 386-25 does today? I don't think so. The computer you buy today may last you a very long time. You may add storage and other peripherals, or a flat-screen monitor, but you won't replace the box.

Hardware innovation is now centered in portable devices, including laptops, and even more importantly, PDAs like the Palm Pilot, now in its third generation. On the other hand, a decade from now, the PDAs we use will make the current generation look like those 386s.

PC-TV convergence is also occurring, but is not really very interesting, except as a social phenomenon. The whole process will be dominated by very large companies; there will be no room for small-scale innovators and innovations of the type that fueled the PC industry from roughly 1975 to 1995.

Software innovation has moved from applications and utilities for the desktop to applications and utilities for portables, and, of course, the Internet.

Despite all the bad PR, Windows, Word, and Visual C++ will continue to dominate their respective markets. In other words, I don't care what people say, you-know-who is here to stay. Maybe, just maybe, toward the end of the coming decade, there will be serious competition, but I would not bet my life savings on it.

Java technology is quite interesting, but Java marketing is slipping badly. If it doesn't turn around soon, Java will die on the vine, or at best become another very small niche supported by a small band of true believers, à la Macintosh and UNIX.

More on PRNGs

We discussed Pseudo-Random Number Generators (PRNGs) in some detail last month. As mentioned, the most popular algorithm for generating a seemingly random sequence of integers is called a Lehmer generator, and it looks like this:

$$x_{i+1} = (ax_i + c) \bmod m$$

The values of the constants a, c, and m are critical. With the wrong values, the sequence will quickly (or immediately) degenerate into a constant value or a simple repeating sequence. So how do you choose good values? The following comments are adapted from section 3.6 of the third edition of Knuth's *The Art of Computer Programming, Volume 2*, "Seminumerical Algorithms." The initial set of comments apply to machine language programming:

The value of m should be large, at least 230.

On a binary computer, choose a so that $a \bmod 8 = 5$. The value of a should be between 1% and 99% of m, and its bit pattern should not be regular. A good choice is a=3141592621.

If a is a good multiplier, the value of c does not matter, as long as c has no factor in common with m, if m is the computer's word size. Good values are c=a and c=1; c=0 is not a good value, unless m is prime. By the way, a Mersenne prime is a prime of the form 2^n-1. The complete list of values of n less than 500 that yield Mersenne primes includes 2, 3, 5, 7, 13, 17, 19, 31, 61, 89, 107, and 127. For more

LISTING 1—RANDOM NUMBER GENERATION IN C

```
/* from Knuth, Art of Comp. Prog., Vol. 2, Seminumerical
 * Algorithms, 3rd ed., p. 185.
 */
#define MM 2147483647                   /* a Mersenne prime */
#define AA 48271
#define QQ 44488                        /* (long)(MM/AA) */
#define RR 3399                         /* MM%AA; RR must < QQ */

long X;                                 /* initialize X<>0, X<MM */
X=AA*(X%QQ)-RR*(long)(X/QQ);
if (X<0) X+=MM;
```

information, see www.mersenne.org.

The least significant bits of x are not very random. It is best to think of x as a fraction (x/m) between 0 and 1. To generate a random integer between 0 and k-1, multiply by k and truncate the result.

In C, without using floating-point arithmetic, Knuth suggests use of a large prime for m, where large means something close to the natural machine size of a word. In this case, c should be 0, and a should be a primitive root of m. See the routine shown in Listing 1, where the value of MM is 231-1. Because MM is prime, the LSBs are just as significant as the MSBs.

Listing 2 shows a routine that, in combination with the routine of Listing 1, gives long sequences ("millions and millions") of random numbers.

LISTING 2—LONG SEQUENCE RANDOM NUMBER GENERATION IN C

```
/* from Knuth, Art of Comp. Prog., Vol. 2, Seminumerical
 * Algorithms, 3rd ed., p. 186.
 * combine with previous routine
 * Z is the output of this routine, 0 < Z < 2**31
 */
#define MMM 2147483399                  /* nonMersenne prime */
#define AAA 40692
#define QQQ 52774                       /* (long)(MMM/AAA) */
#define RRR 3791                                /* MMM%AAA; RRR must < QQQ */

long Y, Z;                                      /* initialize Y<>0, X<MM */
Y=AAA*(Y%QQQ)-RRR*(long)(Y/QQQ);
if (Y<0) Y+=MMM;
Z=X-Y;
if (Z<=0) Z+=MM;
```

Small C Project

I have been experimenting with the Small C compiler published on an occasional basis in Dr. Dobbs Journal going back as far as 1980, and as recently as 1997. Small C is a loose subset of ANSI C that supports pointers, dynamic memory management, integer math, and one-dimensional arrays of char and int types. The compiler has a simple optimizer. There are no structs or unions, longs or floats.

The source code is public domain, with copyright by James E. Hendrix. It's available on the Internet and on a CD-ROM from Miller-Freeman. See www.ddj.com, or call 800-822-1162.

The most interesting thing about Small C is that Small C is written in Small C. That's right; it compiles itself. The interesting thing about that is that you can change and enhance the compiler to suit your needs.

For example, the basic compiler generates code that runs on a PC. However, Small C has been ported to generate code for other microprocessors and microcontrollers, including Z80, 6502, 8051, and 68HC11. In fact, the original version of Small C was built on and for a Z80 running CP/M.

The CD-ROM is valuable because it contains the complete text of Hendrix' excellent and out-of-print book explain-

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LISTING 3—SMALL C BATCH BUILDER

```
@echo off
if (%1) ==() goto SYNTAX
if not exist %1.c goto NOFILE

cc %1
if errorlevel 1 goto BADCOMPILE

asm %1
if errorlevel 1 goto BADASSEMBLE

rem for MS
rem link %1, %1, %1, clib, nul

rem for Borland
tlink %1, %1, , clib
if errorlevel 1 goto BADLINK

Echo Success!
goto END

:NOFILE
echo No such file: %1.c
goto END

:SYNTAX
echo Specify a C file to compile, no extension
goto END

:BADCOMPILE
echo Unsuccessful compile, terminating
goto END

:BADASSEMBLE
echo Unsuccessful assemble, terminating
goto END

:BADLINK
echo Unsuccessful link, terminating
goto END

:END
```

ing basic C programming, compiler use, and compiler modification and enhancement. The CD also contains the source to Hendrix' final version (2.2) of the compiler, as well as the ports mentioned above. In addition, it has another 16 article reprints from Dr. Dobbs, all of which are interesting, and some of which are practical, including one on adding concurrency (multitasking) to Small C.

Some of you may know that I've been playing with Atmel's new line of AVR microcontrollers. Compared to PICs, they're fast and smart, but thus far undersupported by the manufacturer and third parties. (I'm not going to get into the AVR very much here; for that, see my column in our sister publication, **Popular Electronics**.) In particular, there are only two C compilers available, one very expensive, one pretty darned expensive.

With this column, I am initiating a long-term part-time project: porting Small C to the AVR. Even if building compilers is not your cup of tea, I think you'll find it interesting to find out what the process involves. The column will continue pretty much as in the past; I will continue covering a variety of topics each month. In addition, there will also be occasional ongoing coverage of the port. I'll post code samples on the Ingeneering Web site (www.ingeninc.com). Speaking of which, there is a new "Tech Corner" that will support my technical articles and interests, something I haven't done very well in the past. Be sure to stop by.

About Small C

Small C is a command-line compiler. It generates assembly-language source code, which must be assembled and linked to run. Small C comes with an assembler, which was written in Small C and is called (naturally enough) Small Assembler, for which source is also available (on the CD, perhaps elsewhere).

The only problem with the standard distribution is that it does not include a linker. If you have just about any old 16-bit C or assembly development tool, you should have a usable linker. I've successfully used linkers from Visual C++ 1.5, MASM 6.1, and Turbo C++ 3.0. I did a brief search and found copies of version 4.01 of Borland's TLINK, which precedes the one in TC3, posted all over the Internet. I'll post a copy on my site, at least until Borland—whoops, Inprise—tells me not to.

On a 180-MHz Pentium Pro running NT4, a complete build of the entire compiler (about 2800 lines of code) takes only about 15 seconds, so the separate compile, assemble, and link stages are still fast enough to have a highly interactive feel. Listing 3 shows a batch file that produces an EXE from a C source. If an error occurs at any stage, the batch file exits with an appropriate message.

The Small C compiler source exists in four files: CC1.C, CC2.C, CC3.C, and CC4.C. The code is well partitioned among them, so that CC1 and CC2 contain the front end, CC3 contains the expression analyzer, and CC4 contains the code generator.

In practice, this means that if you wanted to add features to the language (*e.g.*, structs), you would work on CC1 and maybe CC2. However, if you wanted to generate assembly language for a different processor, you would concentrate your efforts in CC4. That's the good news.

The bad news is that some hard-coded code-generation occurs in CC1, and the code-generation structures and routines in CC4 are not as cleanly separated from surrounding code as would be ideal. That in turn makes the job of porting more difficult than it could be. However, it's hardly insurmountable either, as we'll see.

In a nutshell, what we need to do is 1) Make the compiler generate AVR assembly code, 2) Rewrite the C library and startup functions in AVR code, and 3) Add support for native functionality of the chip (timers, interrupts, A/D, serial I/O). We'll do so targeting the senior member of the family, the 8515, which has 4K of program space. Later, we will look at supporting other family members, enhancing the language, and so on. In the meantime, stay in touch via e-mail at jeff@ingeninc.com. EN

EQUIPMENT REPORT

continued from page 15

One rotary switch and 10 pushbuttons control all functions on the DMM. A Hold button causes the meter to beep, freeze the display, and turn on an "H" indicator. A Range button first selects the manual ranging mode and then selects the range.

As you can see, the Tektronix TX-3 packs a ton of usability and features in a rugged package that is built to last. If you are serious about your electronics profession or hobby, put this one on your short list of DMMs. For more information on the TX-3, or its sister unit, the TX-1, contact Tektronix directly (Tektronix Measurement Group, PO Box 3960, Portland, OR 97208-1542; Web: www.tek.com/measurement), or circle 15 on the Free Information Card. EN

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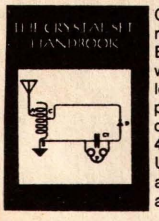

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Prototype

Cell Phone Battery May Soon Be The Talk Of The Town

A new power source for cellular phones, portable computers, and other portable electronic devices promises to deliver power up to 50 times longer than standard nickel-cadmium (NiCd) batteries.

Following a long-time dream of electrochemists to create electric power from hydrocarbon fuel, Los Alamos National Laboratory physicist Bob Hockaday has engineered the prototype of a miniature methanol fuel cell in his basement lab. Financial backing has been arranged to develop a manufacturing prototype. The battery, which he calls the Micro-Fuel Cell, is similar in size and price but just half the weight of conventional batteries. It is expected to have a major impact on the $1 billion a year portable-phone battery market. The new product could be on store shelves as soon as the end of 1999.

ROBERT HOCKADAY AND HIS FUEL CELL in his basement laboratory. The project will soon move to larger quarters to complete work on the manufacturing prototype.

Keep on Talking

Hockaday's methanol fuel cell runs at room temperature like other batteries and will produce power at levels needed to operate a cellular phone—three-tenths of a watt in standby mode and four watts for talking.

The new micro-methanol cell has no moving parts and no metals to wear out and is expected to last at least 20 years, whereas most conventional batteries wear out after two years. More energy means users can leave their phones on for as long as two weeks, not just one day, and can talk for up to 100 hours, compared to just two hours with current battery technology. Refueling the micro-methanol cell is as rapid and simple as pouring in 1.5 ounces of inexpensive methanol, instead of waiting several hours for recharging.

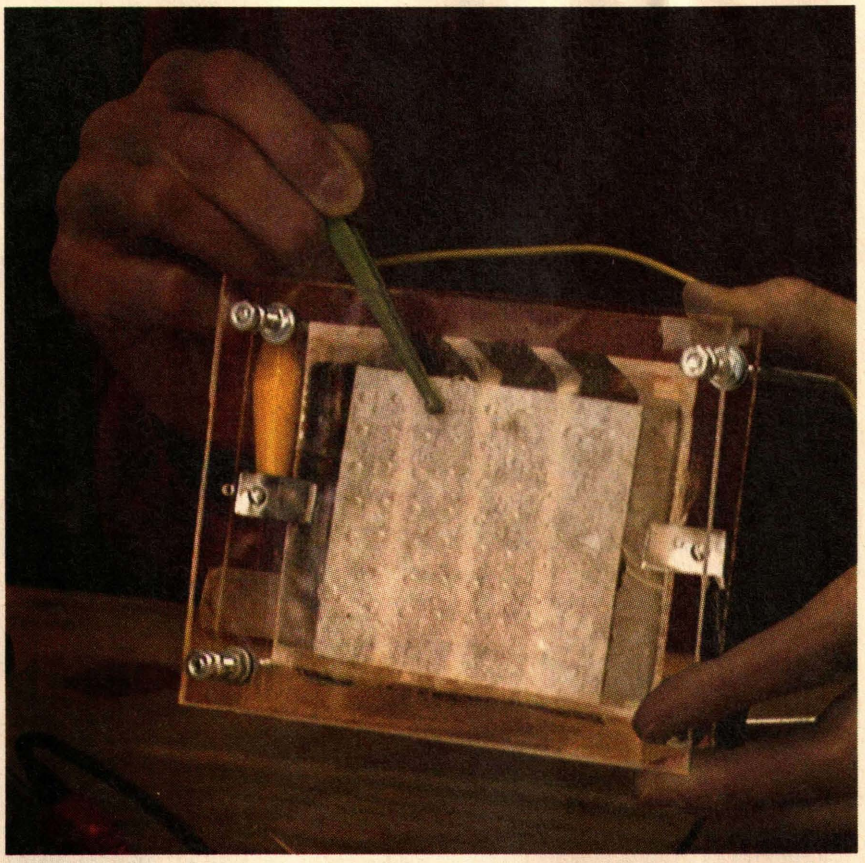
"That's the nature of hydrocarbon fuels," said Hockaday, who holds two international patents, three domestic patents, and has a fourth domestic patent pending. "You can carry more energy per pound. That's why biological systems run on them."

Fuel cells work by converting the chemical energy in a fuel such as methanol to electrical energy by creating a circuit through which electrons in the fuel travel from a negative to a positive, or oxidizing, electrode. The new cells are non-bipolar; that is, the positive electrodes are all on one side and the negative electrodes are on the opposite side. The electrodes provide elementary connections at low power. Getting more power is a simple matter of stacking the fuel cells.

Hockaday says manufacturing will be simple. The same lithography technology used to manufacture printed circuit boards can be used to print fuel cell elements. Millions of the elements can be printed on a single sheet of plastic.

The device is also safe for the environment, presenting none of the environmental headaches of current batteries. "This thing is practically edible," Hockaday jokes. The only waste products are water vapor and carbon dioxide. Nickel-cadmium batteries, on the other hand, can be toxic to humans. When disposed of improperly and the casings degrade, cadmium leaches into the surrounding environment, threatening eventually to reach ground water. Exposure to too much cadmium, for instance, can cause liver and kidney damage.

Hockaday began his fuel cell work 10 years ago. He came up with the idea of micro-engineering fuel cells and using the same type of silicon-chip miniaturization and materials technology that trans-



THE METHANOL FUEL CELL has no moving parts, is safe for the environment, will last 20 years, and can power a telephone for over 100 hours of talk time between recharges.

formed computers from big boxes to laptop platforms. Convinced his patented technology could have a major impact on the multi-billion dollar U.S. cellular phone market, Hockaday created his own company, Energy Related Devices, and in 1994 took entrepreneurial leave from Los Alamos to devote full time to the research. He estimates he has spent $25,000 a year on the equipment that fills the lab beneath the kitchen of his Los Alamos home. Through a cooperative research and development agreement, LANL has provided technical help as Hockaday continued improvements of the fuel cell.

"We're at the point that it really does work. We have a working device," Hockaday said. "We call it proof of principal. Now it's just a matter of brute force engineering to crank it up."

FOR MORE INFORMATION

Manhattan Scientifics, Inc.
2 Penn Plaza, Suite 640
New York, NY 10121
Web: www.manhattsci.com

Coming to Market

LANL's Civilian and Industrial Technologies Program Office introduced Hockaday to investor Marvin Maslow, who set up Manhattan Scientifics to back Hockaday. Maslow's investment will allow Hockaday to move his lab out of the basement into a larger facility to complete work on the manufacturing prototype. Maslow said he plans to work with Hockaday to create alliances with Fortune 100 companies that can bring the product to market quickly.

"The weak link in the chain of electronic devices is the battery," Maslow said. "If the micro-fuel cell invention does what we think it will, it will have a profound impact on people's lives around the globe. The marketplace for this invention is vast."

Next on the horizon for Hockaday are micro-fuel cells for portable computers, which need about 30 watts of power, and other low-draw electronic devices. The military is also interested in using the cell for some of its electrical devices, such as laser sights on rifles or night-vision goggles.—**By Douglas Page** PT

The Art of Noise

NEC Home Electronics, in cooperation with a subsidiary electronics manufacturer, Authentic, has developed the world's first wall-hanging speaker. The ultra-slim "Flat Panel Speakers," which are only 7 millimeters thick, can be fitted to walls like a painting. Indeed, the speakers come with a variety of clip-

LITERALLY PRETTY AS A PICTURE, these speakers can be made to fit in with any decor. (Photo Courtesy of NEC Singapore)

on images, so that you might listen to your favorite Nana Mouskouri album through a landscape picture of Greece, for example.

Loudspeakers transform an electrical signal into an acoustic signal. In conventional speakers, a cone-shaped diaphragm is attached to a coil of wire and made to vibrate in accordance with the electrical signal inside a box. In the Flat Panel Speakers, a Styrofoam actuator emits vibrations over the speakers' entire surface, projecting sound over greater distances and with greater efficiency than conventional speakers.

The speakers, currently available only in Japan, retail for around ¥35,000 ($270).—**Courtesy Look Japan, July 1998** PT

THE SDTF IS A FULL-SCALE, airport operations simulator that has the "look and feel" of an actual air-traffic control-tower cab.

Air Traffic Control Tower Simulator

NASA has begun construction of a full-scale air-traffic control-tower simulator. The facility will provide realistic airport conditions and configurations that will test ways to combat air and runway traffic problems at commercial airports. Jointly funded by NASA's Advanced Air Transportation Technologies Office and the FAA, the $9.3 million two-story building called the Surface Development and Test Facility is being built at Ames Research Center, Moffett Field, CA.

Researchers will look primarily at the feasibility, safety, reliability, and cost benefits of technologies prior to incorporating them into airports. They will be able to simulate any airport in the world. "This will be the only one of its kind in the world," said Stan Harke, project manager at Ames. "It will allow the commercial aviation industry to study and correct potential problems in a safe setting before they become actual problems."

Computer software, provided by Raytheon Systems in Arlington, TX, will be integrated with the tower simulation hardware technologies at Ames to support both radar and out-the-window visual simulation. The facility's second floor is designed to replicate a typical air-traffic control tower. The tower cab will have reconfigurable site-specific displays—such as terminal-area radar, surface radar, and weather—installed based on FAA specifications. Twelve rear-projection video screens will provide a seamless 360-degree high-resolution view of the airport or of other scenes being depicted.

These image generators will provide a realistic view of weather conditions, environmental and seasonal effects, and the movement of 200 or more active aircraft in the air or on the ground. The imaging system will be powered by supercomputers and the remainder of the simulation by approximately 100 Pentium processors. Video cameras will record air-traffic controllers' activities for human-factors research and will also provide remote viewing of the simulations. PT

Interchanging Components

Developing a framework for interchanging electronics assembly equipment and software from different vendors could yield substantial savings in the cost of manufacturing circuit board assemblies for a wide range of applications. Such a "plug and play" capability is the focus of a project at the Georgia Institute of Technology's Manufacturing Research Center (MARC). MARC's printed-circuit-board electronics-assembly facility was chosen by the National Electronics Manufacturing Initiative (NEMI) to be a demonstration test bed site. NEMI is a consortium of electronics suppliers and manufacturers whose primary purpose is to improve the competitiveness of North American manufacturers.

Personnel in the Center for Board Assembly Research (CBAR) in MARC operate the electronics-assembly facility, which initially received more than $3 million in equipment and software from numerous vendors. CBAR contains a state-of-the-art integrated surface-mount/direct-die-attach printed-wiring-board assembly line with extensive automated in-line-post-process-inspection capability. PT

Quantum Transistors

A quantum transistor has been developed at Sandia National Laboratories that could one day lead to computers hundreds of times faster than those available today. "We have demonstrated real circuits that work and are easily fabricated, " says Jerry Simmons, leader of the Sandia Development Team.

The quantum mechanical transistor, called DELTT (Double Electron Layer Tunneling Transistor), is the equivalent of turning on a light bulb without closing a switch: Electrons "tunnel" from path to path through a barrier that, according to classical physics, is impenetrable. In a standard transistor, the route of thou-

sands of electrons is controlled by an electronic switch. In the quantum transistor, the electrons are held back by permanently closed gates. However, when all of the electrons have the same amount of energy and are moving very quickly, they are able to pass through the gate at high speed, effectively switching the transistor on. The high speed of the electrons causes the switching to occur much more quickly than in currently available transistors.

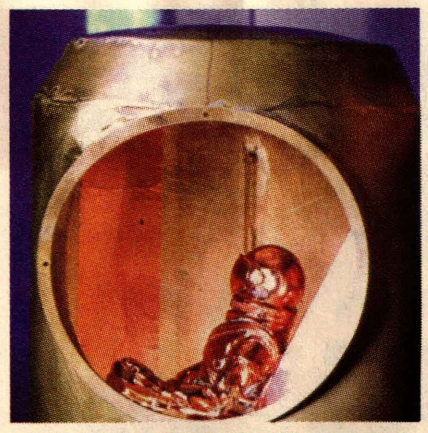
Researchers think this could increase computer speeds by at least ten times. However, predicting the speed is not possible at the moment because the measuring equipment is not fast enough. Possible future uses for the device include being put to work in satellites and smart missiles to process information faster and with less payload and power consumption.

First, practical problems have to be resolved, such as temperature. These transistors now work only at temperatures at or below 77 degrees Kelvin, but rapid improvements are being made. It is expected that the device will be operating at room temperature by next summer. PT

Outer Space Antenna

A unique antenna for the NASA-led International Space Station may soon keep astronauts safe and in touch as they prepare for challenging space walks. Called an Orlan antenna, this two-foot long "loop" design is being developed by Georgia Tech Research Institute (GTRI) for the crew lock, a cramped cylindrical air lock that can hold two space-suited astronauts. Because of its positioning, the sensitive antenna—sometimes known as a "towel bar" model—must survive bashing by space packs and huge temperature swings, and also serve as a hand- and foot-hold for astronauts clambering into space.

The greatest technical hurdle was the antenna's location within the crew lock. In such a resonant cavity, most energy comes back because it doesn't have any place else to go. The special loop design establishes a powerful signal between antenna and astronaut, thereby overcoming the feedback problem via signal strength.



HERE'S A SCALE MODEL OF the crew lock, complete with miniature astronaut with a conductive spacesuit, used to develop the Orlan antenna for the upcoming International Space Station.

The antenna's job is to provide communications for International Space Station astronauts using Russian-designed spacesuits. These spacesuits use the same communications frequency used for many years aboard the Mir, a frequency four times lower than that used by US spacesuits. The longer Russian frequency is only slightly shorter than the crew lock's 65-inch diameter, necessitating use of an antenna so large it must act as a handrail, as well as give strong communications performance.

Dependable operation of the crew-lock antenna is essential. While astronauts wait within the lock sealed into spacesuits, these antennas carry verbal communication between astronauts and crew. They also transmit vital signs and other data necessary to monitor each astronaut's physical condition. For instance, each spacesuit's umbilical cord provides coolant to keep astronauts from overheating inside the highly insulated spacesuit. Temperature data transmitted from the crew lock lets the space station's communications center make sure the cooling system is operating properly.

To develop an optimal antenna design, GTRI researchers first performed calculations using High Frequency Structure Simulator (HFSS) modeling and simulation software by Ansoft. They augmented those findings with their own 1:6 scale model of the crew lock. The researchers even developed a scale model of an astronaut with a conductive spacesuit that simulated the Russian spacesuit. In it, a metallic layer lets the whole suit function as an antenna.

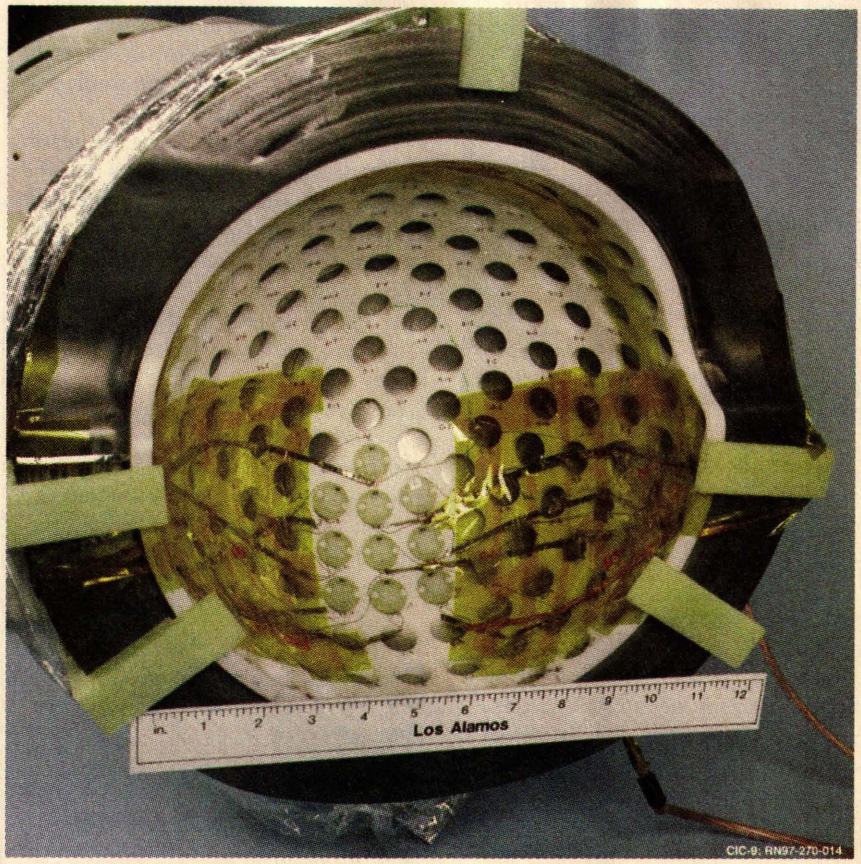
At NASA's Johnson Space Center in Houston, a test of the antenna in The Boeing Company's full-scale crew-lock model produced data that closely resembled data from the scale model. The test loop antenna was made of copper; the final, space version will be high-strength aluminum, which has performance almost identical to copper. While at Johnson Space Center, the GTRI team also tested a second crew-lock antenna design—a "patch" model made of nickel-ferrite, a magnetic material that allowed reduced antenna size. The patch model outperformed the Mir antenna, but came in second to the loop design. PT

Brain-Imaging System

A medical instrument that will help physicians assess patients with brain injuries and diseases, and that might even help solve the mysteries of how the brain works, was recently presented by Los Alamos National Laboratory. The whole-head magnetoencephalography sensor system incorporates new concepts that should reduce the cost of such instruments from about $3 million to less than $500,000, and hence allow many more patients to benefit from the brain-imaging system.

Magnetoencephalography, or MEG, is a method of measuring the tiny magnetic fields produced when groups of the brain's 100 billion or so cells, or neurons, are active. Those fields, a billion times smaller than the Earth's magnetic field and 100,000 times smaller than the field surrounding a household wire, are generated by electrical currents that result from thought, the sound of music, the impulse to move a muscle, and other types of brain activity.

MEG scans can help neurosurgeons pinpoint areas associated with brain injury or functional abnormalities such as epilepsy and help researchers study such disorders as Parkinson's disease, multiple sclerosis, and schizophrenia. It supplements with functional maps of brain activity other imaging techniques such as



A CLOSE-UP VIEW OF THE WHOLE-HEAD MEG (magnetoencephalography) system "helmet". The white material is a newly patented material (DuPont/Los Alamos) that precisely holds each Superconducting Quantum Interference Device (SQUID) sensor in place.

Magnetic Resonance Imaging, or MRI, which displays brain anatomy.

The Los Alamos system looks like a helmet and contains 155 ultra-sensitive sensors, known as Superconducting Quantum Interference Devices or SQUIDs. Atop the helmet is a unique shield that screens out electrical and magnetic interference and an instrument column immersed in liquid helium that maintains the SQUIDs at −450°F.

The SQUIDs record the magnetic fields produced by active neurons and display the fields as topographic maps. Computer models are used to calculate the locations and durations of brain activity and project maps of those active neurons on three-dimensional MRI images of the brain.

Several Los Alamos concepts are being applied in a clinical setting at the VA Medical Center's Neuroimaging Center. Los Alamos, the VA Center, the University of New Mexico, and Sandia National Laboratories have worked together to quadruple the number of patients who can use the system from three a week to 12. Los Alamos also has improved its computational methods to permit more sophisticated analysis of clinical MEG data.

Previous MEG systems have required costly, specially constructed rooms to shield SQUID sensors from external magnetic fields, such as those generated by building wiring and lighting systems. A patented superconducting image surface, the latest breakthrough from Los Alamos, is a unique shield that repels interfering magnetic fields at the same time that it focuses the magnetic fields generated by brain activity, greatly reducing the time needed to measure brain activity. The shield incorporates a cryogenic material similar to Corian, commonly used for countertops in luxury homes. Preliminary tests of the new full-head MEG system have been completed, and initial measurements of human subjects are scheduled. After those tests, the new system will be installed at the Albuquerque VA Center for clinical trials. PT

1.6 GB/s RDRAMs

Toshiba America Electronic Components, Inc. (TAEC) announced that their 72-Mb Direct Rambus DRAM (RDRAM) devices are the industry's first with confirmed 800-MHz or 1.6-gigabytes per second (GB/s) functionality. Samples are undergoing system testing and chipset validation.

"Rambus Inc. has confirmed that our 72-Mb Direct RDRAM devices were first to complete functional tests, including pipelined read/write operations at speed, initialization procedures, and power management operations," said Jamie Stitt, manager, DRAM marketing at TAEC. "In fact," he continued, "based on our characterization results, our first parts achieved better than 2GBs/bandwidth. With plenty of margin at such an early stage, we're confident we can ramp production to meet the industry's needs in 1999."

The devices are manufactured using Toshiba's 0.25 micron process technology. PT

Noisy Water

Ultrasonic analysis can reveal the contents of sealed containers or the structural integrity of solid objects. Now Los Alamos researchers have shown that they can analyze samples of liquids as tiny as a single drop—and without a container. The recently patented technique uses two closely spaced transducers—devices that convert electrical energy into sound and vice versa—or a single transducer and reflector.

Surface tension holds a droplet between the two elements as they subject the sample to a spectrum of ultrasonic frequencies. The response of the droplet yields unique clues to its composition, with a sensitivity of one part in a million. The sample can even be excited with a laser or magnetic field and the induced changes in the sample measured ultrasonically.

Possible applications include detecting minuscule quantities of drugs or measuring the chemistry of droplets of blood, tears, or substances such as bee or snake venom. The method can be applied to small samples of tissue as well, and researchers intend to use the ultrasonic technique as a real-time biopsy tool. PT

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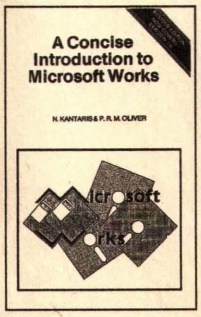

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BY SAM GOLDWASSER
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CD-Player System Problems and Alignment

WHEN LOOKING AT CD AND CD-ROM PLAYERS, IT SOMETIMES SEEMS THAT THERE ARE NO END TO THE PROBLEMS THAT CAN OCCUR. WELL, THERE ARE INDEED A LOT OF THEM, AND WE HAVE BEEN GOING DOWN THAT LIST FOR THE past few months. This time we are going to start by looking into some tracking (play and seek) problems followed by a discussion of CD player servo systems and a general procedure for performing servo alignment—if it is possible.

Kinds Of Failures

Proper readout of the digital audio or data on a CD relies on the focus and tracking servos and the system controller all working correctly. While playing, searching, or seeking, focus must be continuously maintained. And this must be done despite spindle run-out, a moderately warped disc, and minor bumps or vibration.

When the player is running at normal speed (1× for music), the fine-tracking servo keeps the laser beam centered on the track (pits of the information layer) of the CD. At the same time the coarse-tracking servo moves the entire optical pickup, as needed, to keep the tracking error within well-defined limits. Failures, or marginal performance of any one of these systems can result in audio noise, skipping, sticking, or total failure of the seek-and-search operations.

But it is important to remember that those same symptoms can also be caused by a dirty or badly scratched or warped disc, a dirty lens, as well as some other electronic or mechanical problems. So if you run into any of the problems we are discussing here, confirm that the disc is not dirty, scratched, smudged, warped, or otherwise defective. That means that you need to inspect and clean it if necessary, and/or try a different one. If that does not help, clean the lens. Those steps are extremely important. I cannot overemphasize that many apparently unrelated problems can be caused by a bad disc or a dirty lens.

Next, check for obvious mechanical faults like gummed-up lubrication or a worn spindle bearing. Only after making these checks should you consider adjusting any of the servo systems.

Types of Skipping Problems

Skipping generally falls into one of the four following categories:

- It gets stuck and repeats a fraction of a second (1 rotation)
- It gets stuck, jumps back, and repeats a few seconds
- It starts having repetitive noise at the disc rotation rate—about 200 to 500 rpm (3 to 8 Hz)
- It starts skipping continuously, or every few seconds (either forward or back)

Assuming that your CD is clean and undamaged (easy to check: see if the trouble repeats even when you change CDs; if so, you probably have a mechanical problem). Look for dirt in the optical-pickup worm screw, or lack of or dried-up lubrication. Also check for a worn spindle bearing or an electronic adjustment. If the problem appears to be most severe at the beginning of the disc, spindle-motor problems or PLL adjustments are the first things to look for. If the problem is most severe near the end of a disc, spindle bearing, track lubrication, and PLL adjustments are what you need to check.

Short-Distance Skipping

This means jumping forward or backward by a fraction of a second. It may occur only once in a while, or it may sound like the pickup is bouncing across the disc. The most common causes include a dirty lens, dirty or damaged disc, misadjusted fine tracking offset/gain, misadjusted tracking balance, or a weak laser. Obviously, inspect the disc first. Look for badly scratched or smudged areas or any other visible defects. Try another disc. If it plays OK, the problem is obviously the original disc. One other item to try, clean the lens.

Occasional Long-Distance Skipping

If the player works properly for several seconds and then skips forward or backwards by a few seconds, you are looking at long-distance skipping or repeating problem. If it is skipping back, in effect, the player will constantly repeat a section of the CD.

Common causes of this problem include a dirty lens; dirt, foreign materials, or lack of lubrication in the pickup drive; a defective or dirty disc; or mechanical damage that causes the mechanism to bind. But before you check or clean anything, first make sure that none of the player's repeat functions have been enabled! Assuming they are not, next inspect the disc for badly scratched or

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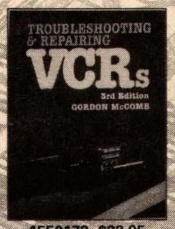

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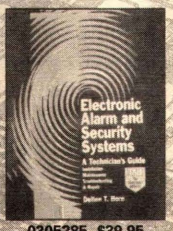

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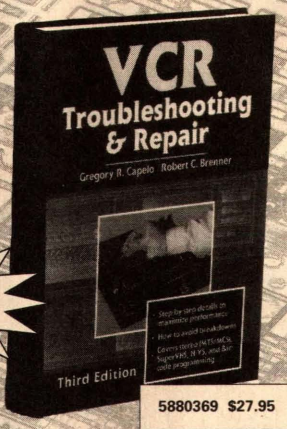

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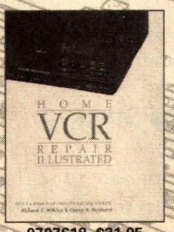

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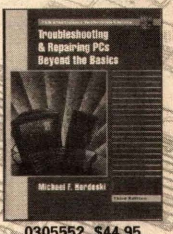

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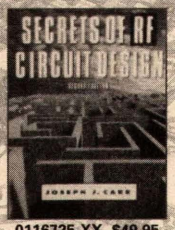

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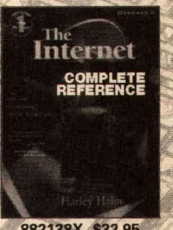

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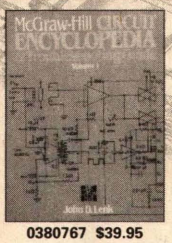

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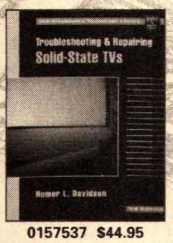

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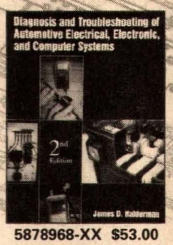
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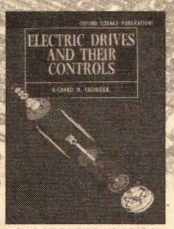

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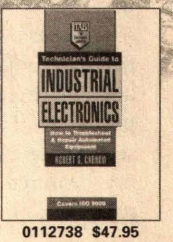

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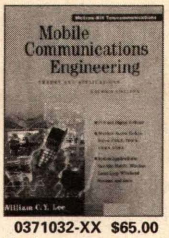

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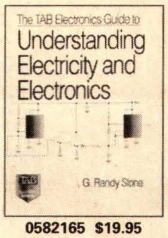

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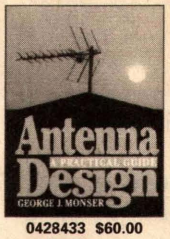

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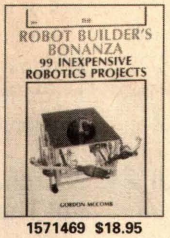

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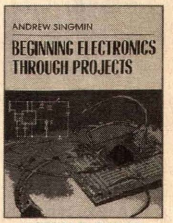

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smudged areas and any other defects, or simply try another disc. If all is well there, try cleaning the lens.

If none of that works, a mechanical fault is likely. These symptoms often are an indication that the coarse-tracking servo is unable to move the pickup as easily as it should. It is probably getting stuck and then either jumping back once the error is too great or breaking free and moving forward in spurts.

Playback Gets Stuck—Rapid Repeat

We are talking about a fault that causes the player to repeat the same track (once around the disc) or even a group of a small number of tracks. The effect sounds like a broken or cracked LP, but at a much faster rate—3 to 8 repeats per second if only one track is being repeated.

The most common underlying cause is a damaged or dirty disc, so don't forget to check the disc first. However, if the tracking (and sometimes even the focus) servos are not properly adjusted, the CD player may become excessively sensitive to disc problems. If the focus or tracking gain is set too high, or if the offsets/balance are not centered, slight disc imperfections, scratches, or dirt can cause the problem.

Player Gets Stuck

When this happens at approximately the same time on a variety of CDs, you've probably got a player that has gummed-up lubrication on its pickup tracks or worm gear. Or there might be some other mechanical problem such as an obstruction or errant wire getting in the way. A flexible cable that has a hairline crack in one or more of its conductors can also produce this symptom. Or, you might have forgotten to disengage the shipping lock!

Carefully inspect the tracks for dirt and gummed-up lubrication. If the player has been in commercial service, always playing the same CD or set of CDs, and now you are attempting to play one that runs somewhat longer, this may happen. Also, if you are attempting to play a CD that contains more than 74 minutes of recorded material, the player may not be able to access the last part of the CD. It may abort the disc or get stuck and keep repeating a fraction of a second or several seconds of the music.

Search and Seek Operations Take Too Long

This means that when you attempt to seek to some specific music track, the operation never completes, or it takes you to the wrong place. Alternatively, even pressing the search forward, or search back buttons may fail to take you where you directed. The player may even abort the disc and stop. If the player is a changer, it may go on to the next disc.

Common causes include a dirty lens, bad disc, tracking or CLV PLL adjustments are needed, mechanical problems with pickup movement, faulty sled-motor drive IC, faulty control logic, or a bad flexible cable.

"Many apparently unrelated problems can be caused by a bad disc or a dirty lens."

If the CD player has a transport-lock screw, make sure that it is in the operate position. Inspect the disc or try another one and clean the lens. Check for the possibility of mechanical problems. Look for a flexible cable with hairline cracks—as the pickup moves past a specific location, a critical connection may open, causing this problem. This is more likely if the player aborts without warning during a seek or search operation.

If none of the preceding items helps, there may be problems in the sled-motor driver, logic, controller, or some other electronic problem.

Search, Seek, or Play Starts OK But Then Loses Time

You've selected music track 5, the player goes there quickly, starts to play, but immediately jumps to another location (forward or backward), or resets to the start of the disc. Or, once play starts, instead of playing forward as would be expected, the numbers in the display count down.

Common causes include a stuck button, need to adjust coarse tracking offset or tracking balance, bad sled-motor drive IC, faulty control logic, or a defective disc. Try a different CD first. If the problem repeats, then you know the problem is not likely to be the disc. While a dirty lens is possible, it is not as common for this kind of symptom. There may also be a problem with coarse tracking offset or tracking balance.

To eliminate the possibility of a stuck button, try operating the player (if possible) with that section of the front-panel control unplugged. See if it works properly if you use the remote control (if the player has one). Or try the press the drawer method of starting play. If any of these result in the disc playing normally, a stuck or dirty button is likely to be causing the problem. You will either have to clean or replace the button.

It is also possible that the sled-motor driver IC or its logic is bad—when the tracking servo is closed, its output is highly unbalanced thanks to an internal failure. Unless you want to take a shot in the dark and replace the chip, further troubleshooting of this problem will require a service manual.

Repetitive Noise

What we are talking about here is a repetitive noise at the disc rotation rate. That means between 500 and 200 rpm (about 3 to 8 Hz), depending upon the track location.

The most common causes are a dirty lens, bent spindle, excessively worn spindle bearing, loose spindle, foreign material on the disc table, disc not firmly clamped, warped disc, misadjusted focus or fine-tracking offset/gain, or a weak laser. As always, check the disc first. Look for badly scratched or smudged areas and other defects, or just try one that you know is good—it works well in another player. If the disc is good, look for a loose spindle (sometimes there is a set screw that needs tightening, or some adhesive may have broken loose). Make sure that there is no dirt or other foreign matter on the spindle table that could keep the disc from seating properly.

Observe the disc as it spins. Is the edge moving up and down by more than a total of about 1 mm? If yes, the disc may be badly warped, or the spindle bearing may be worn causing an unacceptable amount of wobble. Unacceptable wobble is an amount so great that the focus and fine-tracking servos cannot compensate for it. This kind of problem can also be caused by a disc clamper that is not working properly—the drawer closing mechanism may not be quite completing its cycle, or possibly the magnet has weakened. Gently press down on the clamper while the disc is turning. If this does reduce or clear up the playback error and/or if you can feel the disc seat better, this is a possibility.

If the problem developed gradually and has been getting worse, a worn spindle bearing is a definite possibility. Adjusting the focus and fine-tracking offset (or possibly gain) may help. A weak laser can also cause these symptoms, but do not try to adjust laser power until all other possibilities have been tried.

Testing the Sled

Sled problems are always mechanical problems. Binding or obstructions are indicated by any long-distance skipping, jumping, repeating or failure to seek or search past some specific location (time) on multiple discs. Defective or erratic limit switches can cause jamming or overrun at the start or end of a disc, or unreliable reset during startup.

Check first for free movement of the optical-pickup sled on its tracks or bearings. Manually rotate the appropriate motor or gear. If you are dealing with a voice-coil positioner (linear or rotary), gently move the pickup back and forth throughout its range. There should be no sticky positions or places where movement is noticeably more difficult. If there are, look for broken or damaged gear teeth, dirt, or other material that should not be there, or gummed-up lubrication.

Damaged parts will have to be replaced (or repaired—sometimes a fine file, Xacto knife, or even a dental pick will work wonders). Otherwise, cleaning and lubrication may be all that is needed. Remove any dirt and old gummed-up lubricants and relube any tracks and gears using the proper oil or grease.

If these tests do not reveal any problems, check out the pickup motor for open windings, a shorted winding, a partially shorted commutator, or dry or worn bearings. As a double check, disconnect the pickup motor from its drive circuit (extremely important) and run it in both directions using a 3-volt source (2 AA batteries connected in series is fine) to confirm electrical and mechanical operation.

In addition, check for the proper functioning of any limit switches on the optical deck. There will almost always be one for the inner (reset/startup) track, and there may be another for the outer track (end of disc) as well. Run the pickup manually or using the batteries to both ends without forcing. Then check for reliable operation of the switch contacts.

Various Tracking Problems on Portions of Discs:

This means that one part of the disc (start or end) plays properly (or at least with less problems) than another. For example, the disc may play flawlessly until approximately the 30 minute point and then develop noise, skipping, or other similar problems. Common causes include a defective disc, faulty spindle motor, misalignment of spindle table and sled track, and need for CLV-drive adjustment.

"Focus maintains a constant distance to within 1 μm (1/25,000th of an inch!) or so between the objective lens and the disc."

Try some other discs to eliminate a defective disc as a possibility. If the problem is most severe at the start of the disc, the spindle motor may have trouble reaching the required 500 rpm rotation rate consistently.

The spindle table and track on which the sled moves may be misaligned. This is especially likely if the player was dropped or otherwise abused.

An adjustment of the servo that controls the CLV-(Constant Linear Velocity) drive to the spindle motor may be needed. We will discuss servo systems next.

Servo Systems

There are several servo systems in a CD player:

• **Focus** maintains a constant distance to within 1 μm (1/25,000th of an inch!) or so between the objective lens and the disc. This distance must be maintained even with a slightly warped or uneven disc, and—in a portable player—with a certain amount of movement as well. Focus is accomplished with a voice-coil type of positioner (similar to operation of a loudspeaker) using optical feedback from the disc surface.

• **Fine tracking** centers the laser beam on the disc track (to within a fraction of a μm) and compensates for side-to-side run-out of the disc and for player movement. This also uses a voice-coil positioner and optical feedback from the disc surface. (Note: on rotary type pickups, there may be no separate tracking coil as its function is combined with the rotary positioner.)

• **Coarse tracking** moves the entire pickup assembly as a function of fine-tracking error exceeding a threshold or based on user or microcontroller requests (like search or skip). Coarse tracking uses several types of positioners depending on performance requirements. In order of increasing access speed it might either be a worm drive, a gear drive, a linear motor, or rotary positioner.

The linear motor and rotary positioner have no gears and simply use a coil and permanent magnet to move the entire pickup very quickly—similar to a voice coil but on a larger scale. CD-ROMs, especially the high-performance models, usually use that type of actuator to achieve their relatively fast access. With these, there might be some type of lock to prevent the pickup from banging around when the unit is moved with power off. Note: for a CD-ROM drive that uses a caddy, always remove the caddy before transporting the drive or the equipment that it is in. The loading of the caddy often unlocks the pickup permitting it to flop around during movement and possibly being damaged.

A linear motor- or rotary positioner-driven pickup should move very smoothly and easily by hand when unpowered and unlocked.

• **Spindle speed** maintains constant linear velocity (CLV) of disc rotation based on a PLL locking to the clock signal recovered from the disc. Spindle drive is most often done with a permanent-magnet DC motor connected to the disc platform. It may be similar to the other motors in CD players and VCRs, (as well as toys for that matter), or a higher quality brushless DC motor.

Play Adjustments

If you are fortunate, the circuit board in your unit is readily accessible with component markings. For each servo, there will be 1 or 2 pots to adjust. (Note, however, that some CD players have no adjustments! In this case about all you can do is confirm that the lens is clean, and clean and lubricate the mechanism.) Those adjustments will be labeled something like:

1. Focus—F.G. (focus gain), F.O. (focus offset)

2,3. Tracking—T.G. (tracking gain), T.O. (tracking offset), maybe others.

4. Spindle PLL, PLL adj., Speed, or something like that.

Before we continue, we need to provide a couple of warnings: **DO NOT TOUCH THE LASER-POWER ADJUSTMENT**—you could possibly ruin the laser if you turn it up too high. Sometimes, just turning it with power applied can destroy the laser diode due to a noisy potentiometer. This adjustment can only be made properly with the service manual. It may require an optical power meter to set laser output. Very often the adjustment is on the optical pickup itself so it should be easy to avoid, but sometimes it is on the main PC board. The laser optical power output is feedback controlled and unlikely to change unless the laser is defective—in which case adjustments will have little effect anyway.

Second, **DO NOT JUST GO AND TWEAK WILDLY.** You will never be able to get back to a point where the disc will even be recognized (without test equipment and probably a service manual).

Now we are ready to start. First, somehow mark the **EXACT** positions of each control. Some of the controls might require quite precise setting—a $^1/_{16}$ of a turn could be critical, especially for the offset adjustments. Sometimes, there will be marked test points, but even then the exact procedure is probably model dependent.

Adjustment Procedure for Noise or Skipping:

The assumption here is that you can get the disc to play but there is audio noise, skipping, or another similar problem.

Play a disc at the track that sounds the worst—put it into repeat mode so it will continue for awhile. Get it to play by whatever means that works.

Repetitive noise at disc-rotation frequency: Try to locate the adjustments for focus. Try the focus offset first, just a hair in each direction. If you go too far, you will lose focus lock totally, the servo will go into focus search mode and/or the unit will shut down. Return the control to the exact original position if there is no improvement. You can also try gain, but in my experience, the gain controls are not critical to normal play but determine how the unit will handle dirty and/or defective discs. However, if they are way off, there could be general problems. Too low a gain setting (this applies to focus as well as tracking) will make the unit very prone to skipping as a result of minor bumps. Too high a setting will make the unit skip as a result of minor disc defects.

Short distance skipping or sticking: Try to locate the adjustments for tracking. Try the fine tracking offset first, adjusting just a hair in each direction. If you go too far, you will loose servo lock totally, the pickup will slew to one end of the disc, and/or the unit will shut down. Return the control to the exact original position if there is no improvement. Then try the other tracking offset if there is one and also the gain (though this is probably not the problem).

"Do not touch the laser-power adjustment—you could possibly ruin the laser if you turn it up too high."

Always return each control to its original position after the test so you don't confuse things more.

General servo adjustment procedure: If you have a service manual for your player, by all means follow its recommendations or at least read through its adjustment procedures before attempting the one given below. If you have an oscilloscope of at least 5-MHz bandwidth, using it to monitor the RF test point during these adjustments will be of great value. However, a scope is not essential.

- Once focus lock is established, there should be a strong signal at the RF test point—typically around a volt or so. It may initially appear somewhat random, however.
- Once tracking lock is established, this signal should appear similar to the "eye" pattern that we will discuss next time. However, while seeking, this may be jumping around somewhat as it attempts to home in on the correct track location.

If your CD player has a test mode, this procedure may be modified somewhat. We will discuss one particular series of players—those from Pioneer—next time. The following procedure is for a typical unit without such a test feature. It assumes that the unit is functional but internal controls are not in their correct position. This might be the case if you violated the second rule above—never wildly tweak any internal adjustments—or if a major subassembly like the optical pickup or main PC board has been replaced.

If you have not touched the internal controls and no major parts have been replaced, there is no need to perform this procedure!

The following are assumed:

- Controls on the main board are in an unknown state but any laser power adjustments have not been made (hopefully, these were on the optical pickup itself or its flex cable and were not touched).
- The player is otherwise functional—there is no physical damage.

You may need to modify this procedure based on your particular model. Some of the adjustments may go by different names or be non-existent. Use your judgment. Except for the laser power adjustment, which should be avoided, it is unlikely that any settings of these controls will result in permanent damage.

Some of these adjustment will need to be performed while the unit is in the startup sequence attempting to read the disc directory. Until focus and possibly tracking and CLV lock are established, it may give up fairly quickly. You will just need to keep cycling power or opening and closing the drawer to get it to repeat the attempt. Once some subset of the servo adjustments are set within reasonable limits, the player may continue to spin the disc ad-infinitum.

Again, hopefully, the adjustments on your player's main board are clearly marked. This is not always the case! Use both your eyes and ears. The following may not apply but are probably worth considering:

- If the sled slews to one end of the track immediately upon power-on or loading of the disc, there may be a coarse tracking balance control that is set incorrectly.
- If the disc does not start spinning at all, focus lock is probably not being achieved. Concentrate on the RF and focus adjustments.
- If the disc spins hesitantly or in the wrong direction, or the sled slews to one end of the track after the disc starts spinning, there is a good chance that the tracking adjustments need attention.
- If the disc goes into overdrive, check the PLL/VCO/CLV adjustment (whatever it is called on your model).

• If the disc starts spinning and continues to spin at the correct speed (500 to 200 rpm depending on track position) without the player shutting down, a valid data-stream is probably being read. This indicates at least marginal RF, focus, tracking, and PLL/VCO/CLV settings. This doesn't mean you can ignore these adjustments but at least it is progress!

• If the disc directory (TOC) is read successfully but the player has trouble locating a track to begin play (even track 1), concentrate on the tracking adjustments—focus and PLL/VCO/CLV are probably fine.

• If the player basically works but there are noise or tracking problems, there is no need to go through this entire procedure—see the simplified one for noise and skipping above.

We are now ready to begin the general servo adjustment procedure:

1. Precisely mark the current positions of all internal adjustments—just in case they were already set correctly!

2. Set all main board controls to their midpoint.

3. Adjust TR BAL (Tracking Balance) to the center of the range over which the sled remains stationary. Outside this range, the pickup will slew to one end or the other. Not all CD players have this control. A CD may need to be in place for this adjustment to have any effect. If you are unable to get the pickup to remain stationary, try fine tracking offset (TR.OFF) as well.

The following two items should be done with no disc in place. If your player does not have suitable test points or if these controls have no effect without a disc in place, skip them.

4. While monitoring the test point for focus error (*e.g.*, TP.FE), adjust focus offset (FO.OFF) for 0 volts (± 10 mV or so). This may not be the optimal setting but will get you in the ballpark.

5. While monitoring the test point for tracking error (*e.g.*, TP.TE), adjust fine tracking offset (TR.OFF) for 0 volts (± 10 mV or so). This may not be the optimal setting but will get you in the ballpark.

6. If you have a DMM, VOM, or scope, put it on the Focus OK test point if there is one.

7. Load a disc and press play if necessary to initiate the startup sequence.

8. Confirm that focus is established. There is an adjustment range for Focus Offset over which focus will be reliably achieved. Outside this range:

• The lens will hunt up and down—possibly with clicking sounds as it bumps into the end stops.

• The Focus OK test point will not be asserted or will be jumping around as well.

• The disc may never start spinning or spin erratically (model dependent).

• Single play units will give up and enter stop mode with a display of "disc", "no disc", "error", etc. Changers will come up with similar display and then move on to the next position in the carousel or magazine.

• Center the focus offset within the range for which focus is stable if it was not already there.

At this point there is a fair chance that the disc has started to spin and even that the disc directory has been displayed. If not, there are still two sets of adjustments remaining.

9. With focus stable, the disc should spin up. It needs to reach and lock at about 500 rpm—roughly 8 revolutions per second. If it does not move or overspeeds, try adjusting the PLL/CLV control (may be called PLL.ADJ, VCO.FR, CLV.ADJ, *etc.*). Note: This assumes that the spindle motor and driver are in good condition. **WARNING:** If the disc spindle speed runs away, turn power off and wait for spindle to stop completely. The PLL/CLV control may be set too high; turn it counterclockwise 1/4 turn and try again. There will be some range of this control where the speed will not run away but will be within the required limits.

Now, there is an even better chance that the disc has started to spin and that the disc directory has been displayed. If not, there is still one set of adjustments remaining.

10. Fine tracking offset may still not be quite right. Try some slight adjustments on either side of the current position. You may have to cycle power or open and close the drawer if you go too far. You might need to alternately tweak both the fine tracking offset and PLL/CLV adjustments.

Hopefully, you now have a disc directory and play is operational, though perhaps with audio noise and/or skipping or sticking.

The following are best done with a scope monitoring the "Eye" pattern or other test points but if you do not have a scope, use your ears.

11. Adjust the PLL/CLV control to midpoint of range in which disc plays correctly. Test this at both the start and the end of a full length (74 minute) disc. The optimal setting will result in the control being centered within the range over which the player works reliably at both ends of the disc.

12. Adjust any RF Offset (RF.OFS) control to the midpoint of the range over which play continues normally with no audio noise.

13. Set Focus Gain (FO.GAIN or FO.G) to the midpoint of the range over which it locks. **CAUTION:** The disc may enter a runaway state if you go too far. Check at both the beginning and end of the disc. Focus gain may need to be increased if the player is overly sensitive to bumps or disc wobble. It may need to be decreased if sensitivity to disc defects is too high.

14. Set Tracking Gain (TR.GAIN or TR.G) to the midpoint of range over which it locks. **CAUTION:** The disc may enter a runaway state if you go too far. Check at both the beginning and end of disc. Tracking gain may need to be increased if the player is overly sensitive to bumps or disc wobble. It may need to be decreased if sensitivity to disc defects is too high.

15. Press stop and then play again to confirm that the disc loads properly, the directory comes up quickly, and the music starts without excessive delay, hunting, or hesitation.

16. Test forward and reverse search and seek functions for proper behavior. Some slight adjustments to tracking balance or fine tracking offset may be needed to equalize the forward and reverse search or seek speed.

17. The player should now operate normally. However some tweaking of the gain controls may be necessary (as described above) for optimum defective disc and track seek performance over entire disc.

If you have an oscilloscope capable of at least 5 MHz bandwidth, you can now optimize the amplitude and stability of the "eye" pattern at the RF test point by going back and touching up the various offset (RF, focus, fine tracking) adjustments. Unless otherwise instructed by the service manual, it is probably safe to assume that the RF signal should be maximum when everything is properly adjusted. For example, if the tracking offset and/or E-F balance is not set properly, you may find that the RF signal amplitude *decreases* when the tracking servo is closed since the laser beam is

(Continued on page 68)

NEW PRODUCTS

USE THE FREE INFORMATION CARD FOR FAST RESPONSE

Pocket Digital Camera

SMALL IN SIZE (3.15 BY 4.0 BY 1.3 inches) and lightweight (under 10 ounces), the Fujifilm MX-700 Digital Camera is easy to carry around in your pocket. Ideal for publishing images into documents, catalogs, web pages, and the Internet, as well as for printing out high-quality images to a printer, the MX-700 features sharp pictures with high resolution and 24-bit color.

CIRCLE 20 ON FREE INFORMATION CARD

The camera uses a Fujifilm-designed $^1/_2$-inch charge-coupled device (CCD) with 1.5-million square pixels. Further enhancing the image quality are the RGB color filters. The MX-700 also features an autofocus lens with macro capabilities, and a 2-inch Poly Silicon LCD monitor that reduces glare.

Data can be transferred from the camera in three ways: via removable storage cards, floppy disk adapters, or serial cables and software. For fast data transfer, the MX-700 records standard JPEG images in about five seconds on the SmartMedia removable storage cards. The cards also allow users to transfer almost instantaneous digital images directly to their desktop. The camera is also bundled with both Windows and Macintosh serial cables and data-transfer software for downloading images. The optional SmartMedia Floppy Disk Adapter makes the MX-700 compatible with virtually any PC. It transfers the digital data directly to a PC's floppy disk drive. Via composite video output, the camera can also be connected to a TV screen to display the image in a slide slow presentation for business meetings or for family viewing.

The MX-700's on-screen programming offers a host of image capture and playback modes. The Function Dial allows users to select the flash mode, to set the resolution for either 1280 by 1024 or 640 by 480, to determine the image sharpness, and to set the time and date. Its Manual Record Mode adjusts brightness and flash intensity, and offers five white balance settings to accommodate various lighting situations. In the Playback Mode, the zoom function provides image preview and the ability to move around nine different areas within the frame. Finally, the Macro Mode captures images as close as 3.5 inches.

The MX-700 comes with a plug-in recharging system. The camera has an estimated street price of $799.

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PC Scanner

POLICE CAR CHASES, EL NINO disturbances, and more, can be tracked through your PC with a scanner recently introduced by Sony. The ICF-SC1 PC Radio Frequency Scanner is the first with a turnkey package that gives you controlled access of the airwaves with the click of a mouse. Its bi-directional PC interface with search and control capabilities lets you connect the scanner to a PC for total control of scanning from either the PC or the scanner, using the supplied PC-control software. By placing searching options in front of your eyes—in the form of icons on the computer screen—it eases operation and increases control.

The scanner allows users to tailor searches and create custom files for easy access to favorite listening areas. The supplied CD-ROM lists more than 3 million records of FCC-licensed radio frequencies in the U.S. There is one-button access to these frequencies, including public safety, aviation, weather, marine, FM and TV.

One feature of this scanner is PLL

CIRCLE 21 ON FREE INFORMATION CARD

synthesized scanning that uses phase-locked loop triple-conversion superheterodyne circuitry for accurate, stable tuning, and to help minimize fading and interference. Other features of the scanner include 300-channel memory; scanning of all possible frequencies—from 25 MHz to 1300 MHz; nine-band reception; AM, narrowband FM, and wideband FM detection modes; and an intelligent active memory system.

The ICF-SC1 measures 7- by $2^5/_8$- by $1^3/_4$-inches and it weighs $13^1/_2$ ounces with batteries. It comes with a variety of scanning options, including band-, programmable-, memory- and intelligent-memory-scanning, and priority scan. Manual tuning is done by pressing the keypad. The backlit LCD makes it easy to see mode, memory page, memory indication, battery warning, detection mode, frequency, and other functions even in the dark. Three-way power operation permits use of the scanner with batteries, the car battery, or on AC power with supplied adapter.

The radio scanner includes the CD-ROM, interface cable, interface software, a helical antenna, and a supplied frequency guidebook. An included belt holder allows the scanner to be securely clipped to a belt, allowing hands-free operation. It sells for $429.95.

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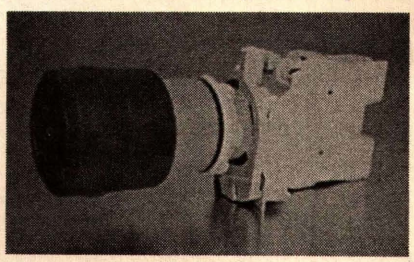
Emergency Stop Switch

EMERGENCY SITUATIONS CALL for fast, reliable action. When you need to stop a machine, a process, or a piece of equipment quickly, 44 Series emergency stop switches give the assurance of rapid, positive response.

For greater security, reactivating the switch requires a deliberate twist of the knob, or for even greater protection, unlocking with a key. The 44 Series emergency switches have bright red caps and meet European standards for foolproof operation. Bright yellow legend plates and enclosures are also available.



CIRCLE 22 ON FREE INFORMATION CARD

The switches have operating temperatures of -12 to 140 degrees F. The 44 Series switches come in either 1 NO/1 NC with a twist release or 2 NO/2 NC contact configurations with a twist or key release. Prices range from $19.95 to $29.95.

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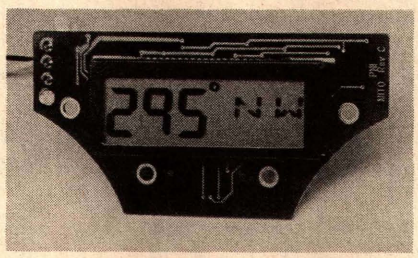
LCD Compass

IDEAL FOR USE IN RV, SNOWmobiles, motorcycles, boats, and van/ truck conversions, the Navifinder-200 electronic compass module (1.75- × 3.47- × 1.19-inches) can easily be mounted in a dash or enclosed in a housing. It's easy to set up, taking less than two minutes to calibrate; and it is simple to use, because it continuously displays your exact heading.



CIRCLE 23 ON FREE INFORMATION CARD

The Navifinder-200 uses advanced calibration algorithms that discriminate between the Earth's magnetic field and those generated externally, such as from the metal and electronics in a vehicle. By electronically compensating for these external factors, this compass is able to provide highly accurate readings in all vehicle environments.

Highly reliable and rugged, the unit is easily hooked up to any 12-volt battery supply and ignition system, or an externally mounted on/off switch and battery. It outputs the compass heading on an LCD in 5 numeric digits and 8 cardinal points (N, NE, E, SE, etc.), with an accuracy of 2°. To provide different viewing angles, the Navifinder can be mounted with up to ±30° of tilt without losing any accuracy. The compass utilizes Magneto-Inductive (MI) magnetic sensor technology, which provides a high sensitivity, a large dynamic range, and low power consumption. The Navifinder-200 is priced at $75 in single units. For quantities of 1000, the price becomes $32 per unit.

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Web: www.precisionnav.com

Portable Wrist-Strap Monitor

DESIGNED FOR FIELD-SERVICE use, the Model GAM-10 Personal Grounding Meter can be used with any standard single-conductor wrist strap. The GAM-10 continuously monitors the integrity of a person's connection to ground, virtual ground, or low impedance. The coil cord is plugged into the unit's wrist strap jack and then connected to either a wrist strap or ESD smock. The virtual ground snap is for the lead wire that connects the unit to a virtual ground.

A red LED and audio alarm indicate Pass/Fail conditions if the higher or lower resistance limit is reached or if any part has become disconnected. There isn't any on/off switch to worry about. Inserting a coil cord's banana plug into the monitor automatically turns it on and withdrawing it turns it off. Its impedance-type wave-distortion circuitry has been proven in the field.

The monitor is compact, measuring

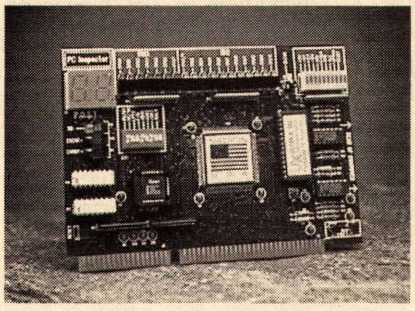
CIRCLE 24 ON FREE INFORMATION CARD

$2^1/_4$ by 5 by 1 inches, lightweight, and has a stainless steel clip so that it can be worn on a belt. It is powered by two AA batteries and an audio warning sounds if there is a low battery reading. The Model GAM-10 costs $149.

PILGRIM ESD TECHNOLOGIES
79 Summit Avenue
Sea Cliff, NY 11579
Tel: 516-674-3649
Web: www.dac.net/pilgrim

Diagnostic Card

DESIGNED FOR TECHNICIANS, MIS professionals, system engineers, and system integrators, PC Inspector is an advanced POST-code reader card for multi-function testing of AT 386 through Pentium II (including all AMD and Cyrix processor and MMX technology) computers. The card provides users with visual digital indicators for identifying POST error codes, monitoring power-supply voltages and system bus signals, and detecting IRQ and DMA conflicts. Furthermore, the card has an on-board Flash ROM for testing system peripherals.



CIRCLE 25 ON FREE INFORMATION CARD

When installed in any standard I/O slot, the PC Inspector will monitor the system's Power On Self Test (POST) codes. When an error is detected, the test sequence is halted at the failing test error code and that code is displayed on the unit's on-board display. The User's Guide explains the meaning of the error code. PC Inspector supports all BIOS that output POST error codes.

The card uses four discrete on-board LEDs to monitor key power-supply voltages. If any voltage is absent, the corresponding LED does not light. Other on-board LEDs continuously monitor critical system signals such as System Clock, Oscillator, Address Latch Enable, CHCK, CHRDY, AEN, RESET, and Watch-Dog Signals. Another set of LEDs is used in testing for IRQ and DMA conflicts. For advanced testing of "completely dead" systems using an oscilloscope, users can even attach PC Inspector's reset line to the motherboard's reset jumper. This feature activates the reset every two seconds, allowing users to quickly test all system lines without manually having to reset the computer between each one.

That card is also equipped with a Flash ROM for testing system peripherals. PC Inspector comes with a manual that describes the complete use of the card as well as describing error codes from all major BIOS manufacturers. The PC Inspector costs $569.

ULTRA-X INC.
1765 Scott Blvd., Suite 101
Santa Clara, CA 95050
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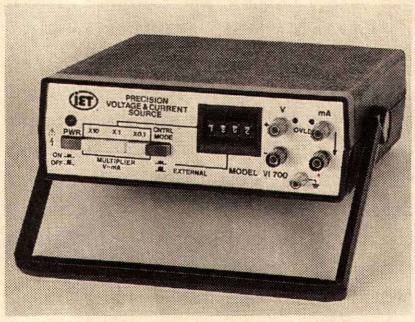
Fax: 408-261-7077
e-mail: pcdiag@ultra-x.com
Web: www.uxd.com

Voltage and Current Source

THE VI-700 IS A VERSATILE AND cost-effective precision dialable or remotely programmable voltage and current source. It fulfills a variety of laboratory needs, and the option of rechargeable battery operation makes it suitable for field use.

The unit features 0.5 Least Significant Digit (LSD) accuracy. Its three ranges provide up to 200V full scale down to 100 μV resolution, and 200 mA full scale down to 0.1 μA resolution.



CIRCLE 26 ON FREE INFORMATION CARD

Both voltage and current outputs are available simultaneously. Output can be set by a range selector and thumbwheel switches in the local mode or by a digital input at the rear panel. This control is available as an IEEE-488 or a BCD parallel interface.

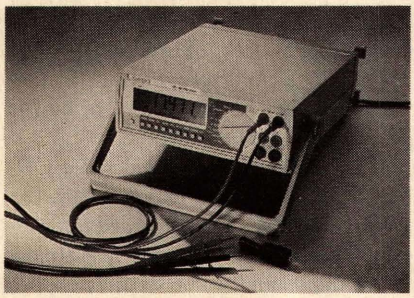
The unit offers many full-performance features: wide output range (up to 200V), low output impedance (5 mΩ), low noise and ripple, and 70mA load current capability. The VI-700 is designed for a number of applications, such as simulation, calibration, A/D and D/A evaluations, and product development.

The VI-700 is AC powered, measures 8.5 by 2.8 by 9 inches, and weighs 5 pounds. It is priced at $679.

IET LABS, INC.
534 Main Street
Westbury, NY 11590
Tel: 800-899-8438 or 516-334-5959
Fax: 516-334-5988
Web: www.ietlabs.com

Bench DMM

WITH A 50,000-COUNT, 0.025% accuracy, the Model 5490 Bench DMM offers a compact, versatile bench test instrument capable of wide-ranging test measurements.



CIRCLE 27 ON FREE INFORMATION CARD

The 5490 features full DMM measuring capabilities including DC voltages to 1000 V at 0.025% accuracy, AC voltage with true rms (AC or AC/DC), and overvoltage protection (1100 VDC+AC peak). The DC and AC current-measuring ranges are from 500 mA to 10 A, the resistance ranges are from 0.01 ohms to 50 megohms, and the capacitance ranges are from 10 pF to 50,000 μF. The unit provides 600 VDC capacitance/resistance. It measures frequency over the range of 0.95 kHz to 500 kHz.

Weighing only 3.8 lbs., the 5490 is compact and equipped with non-skid pads—ideal for bench or lab use. A 50,000-count resolution LCD offers easy-to-see readings, supported by a 34-segment analog bargraph. For data logging and record/printout capability, the unit features a built-in RS-232 port. The 5490 is priced at $675.

B&K PRECISION
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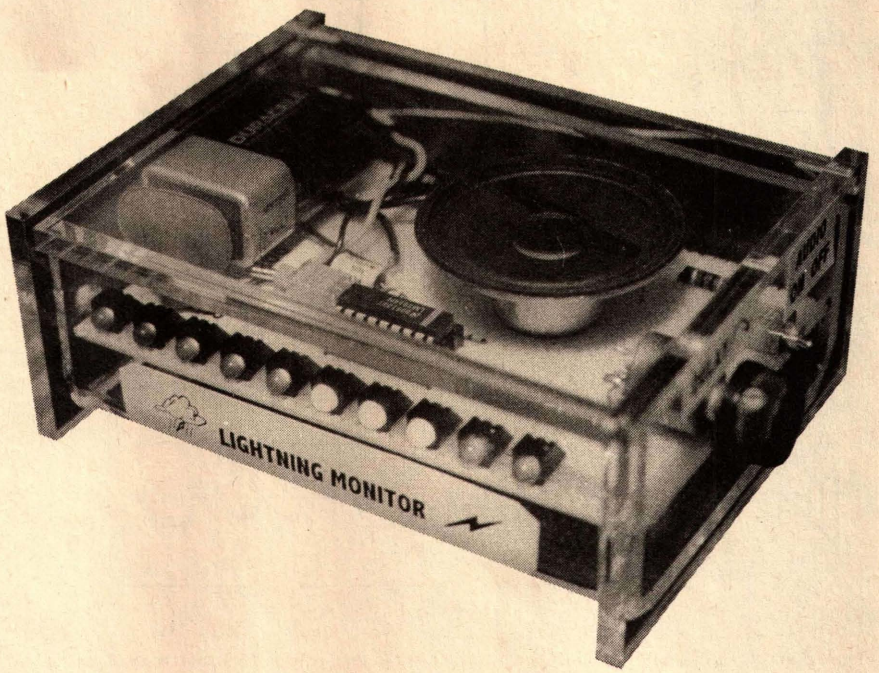
Web: www.bkprecision

EN

STORM-WARNING LIGHTNING MONITOR



Plug this simple circuit into an AM radio, and you'll know well in advance of any approaching thunderstorms.

KENTON CHUN

Although discussions of El Ñino are no longer front-page headlines, the unpredictable weather—including violent thunderstorms—has always been here and likely always will. For example, an estimated two-billion dollars worth of damage is caused every year by lightning. Some electronics manufacturers are reluctant to make good on warranties if the cause of the failure was due to a lightning strike. With more surge-sensitive equipment coming into everyday use, our world has become more susceptible to "technological shutdown" from lightning hits.

In addition to property damage, lightning strikes are dangerous. Last year, over 200 people were struck and killed by lightning. Your odds of being hit by lightning are said to be better than winning the lottery!

Look around your home. If there is a tall antenna mast or tree on or near your property, the statistical chances of a lightening hit are greatly increased. Although tall, grounded objects around you or your home will tend to protect you from direct hits, the damage done by a nearby lightning strike is not something that should be taken lightly. Even after it gets into the ground, lightning will travel long distances before it dissipates—following buried pipes and cables that act as conductors; the electrical charge can resurface anywhere. For example, although a ham-radio mast might be well grounded, it is always a good idea to disconnect any equipment from the antenna when a storm is approaching.

A direct or nearby strike can take out much more than just the radio. One example that the author is familiar with occurred in an office that decided to do their own local-area-network wiring. They decided to save installation costs by having their in-house electrician run the cables. Several of the cables were hung from the overhead sprinkler pipes. Soon, certain computers began to break down on a regular basis. The common factor between them was that they were all connected to cables that were strung up against hundreds of feet of "grounded" overhead sprinkler pipe. When it was suggested that lightning was the culprit, the electrician argued that grounded pipes should not be above ground potential, even when struck by lightning.

It was eventually verified that the EMF pulses from nearby lightning strikes were being induced into the LAN wire by the sprinkler system. Although the cause of the malfunctions was eventually found, it was at a high cost in both lost hardware and time—all for the desire to save a few dollars!

The Nature of Lightning. Lightning is an electrical discharge that re-balances the differences between positive and negative charges within a cloud, between two clouds, or between a cloud and the ground. Cloud-to-ground strikes generally cause the greatest amount of property damage and injury to life. The negative charge at the cloud's base is attracted to the positive charge at the earth's surface, which causes the initial contact. An actual lightning strike consists of two separate events—a strike leader and a return stroke. When the electrical potential is great enough, a small strike leader will leap from the cloud to ground, ionizing the air as it goes. The return stroke flows back up the ionization path into the cloud creating the larger flash and discharge that we associate with lightning.

Due to the large voltages involved, a lightning strike creates a broadband EMF pulse of tremendous magnitude. Those pulses can easily be detected a hundred miles away. When a storm approaches,

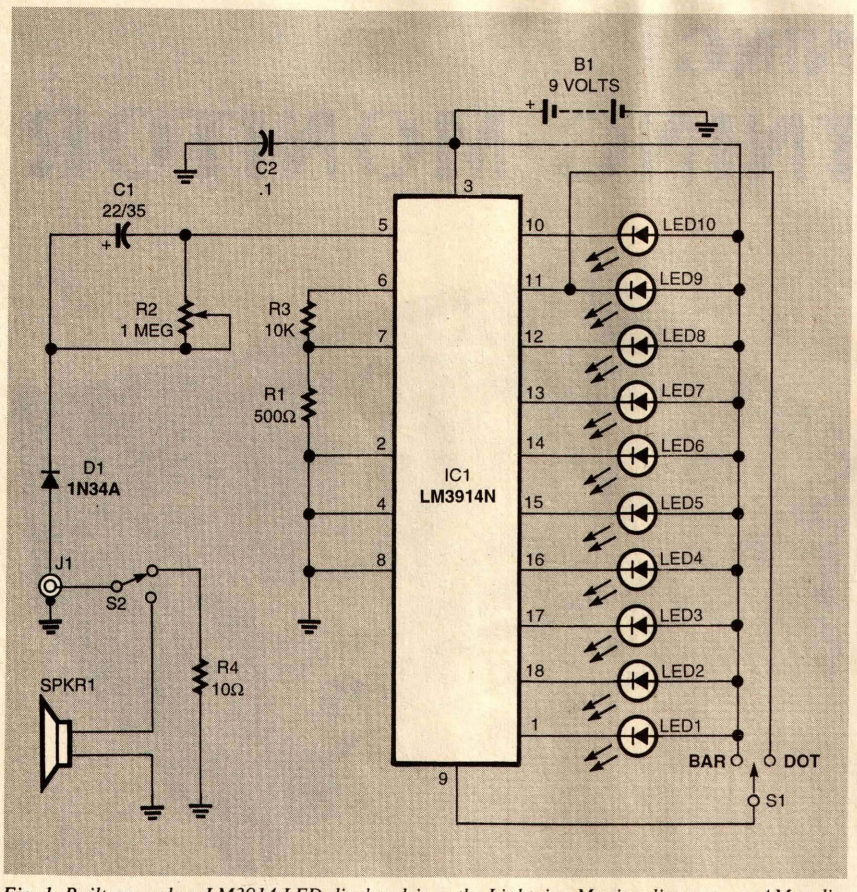


Fig. 1. Built around an LM3914 LED display driver, the Lightning Monitor listens to an AM radio. When a pulse from a lightning strike is detected, the LEDs light up. The amount of time that they remain lit is adjustable so that you have time to notice the warning.

the frequency and field intensity of the EMF pulses will increase. We can take advantage of that phenomenon to "detect" the presence of an approaching thunderstorm.

By nature, a bolt of lightning is an excellent amplitude-modulated (AM) signal. Many of us have heard lightning strikes on an AM radio. Because of the broadband nature of the pulse, the crackle of a lightning strike can be heard anywhere on the AM dial. Although you can simply leave the radio on all of the time, it is impossible to pay attention to it all of the time. Moreover, our sense of hearing is not very acute—our brains have learned to "tune out" noise. To overcome that problem, we need some way to draw our attention to the possibility of an approaching storm. That task is nicely handled by the Lightning Monitor that we will now describe.

How It Works. The Lightning Monitor is a simple circuit that listens to an AM radio signal continuously. The circuit diagram is shown in Fig. 1. The heart of the circuit is IC1, an LM3914N display driver. That chip is designed to show a voltage reading on a set of light-emitting diodes. Within IC1 are a voltage divider and ten comparators that turn on in sequence as the input voltage rises.

The audio output from an AM radio is applied to J1. If you want to hear the radio signal, S2 switches the audio signal between the Lightning Monitor circuit and SPKR1. When the speaker is not in use, its load on the radio is simulated by R4.

The audio signal is changed into a half-wave DC signal by D1. The semi-rectified signal is applied to C1, charging it up. During the non-charging portion of the half-wave signal, C1 is discharged by R2. Since R2 is adjustable, the discharge rate of C1 can be set to match the audio characteristics of the particular radio being used. The rate of discharge can be varied between almost instantaneously to several seconds.

Normally, the audio signal will hold the voltage on C1 steady with some fluctuation as the audio gets louder and softer. When a pulse from a lightning strike surges through the radio, C1 charges much faster than it discharges.

The voltage on C1 is sensed by IC1 and the current level displayed on the LEDs. Since IC1 can display a voltage level as a "bar" of LEDs or as a single moving dot, S1 is used to select between the two display modes.

The circuit is powered by B1, a 9-volt battery, although any source of well-filtered DC power between 5 volts and 18 volts will work well. In fact, if the circuit is to be left on all the time, you'll almost certainly want to use an external power source. That's because should B1's voltage drop below IC1's minimum supply requirement, the comparators within that IC, and hence the unit, will not be reliable.

Building the Lightning Monitor. The Lightning Monitor circuit is simple enough to be built on a piece of perfboard using standard construction techniques. The size of the LEDs and their colors depend on your own personal preference. If you want to arrange the display similar to other color meter displays, use green LEDs for the first six units, followed by two yellow LEDs and two red LEDs at the high end. All of the connections should be kept as short as possible.

The Lightning Monitor can be housed in any suitable case. If you are exceptionally neat in your board construction, you can use a clear plastic box similar to the author's prototype shown in Fig. 2. If your radio has enough room inside its case, you can even mount the Lightning Monitor inside that case and use the radio's power supply to power the circuit.

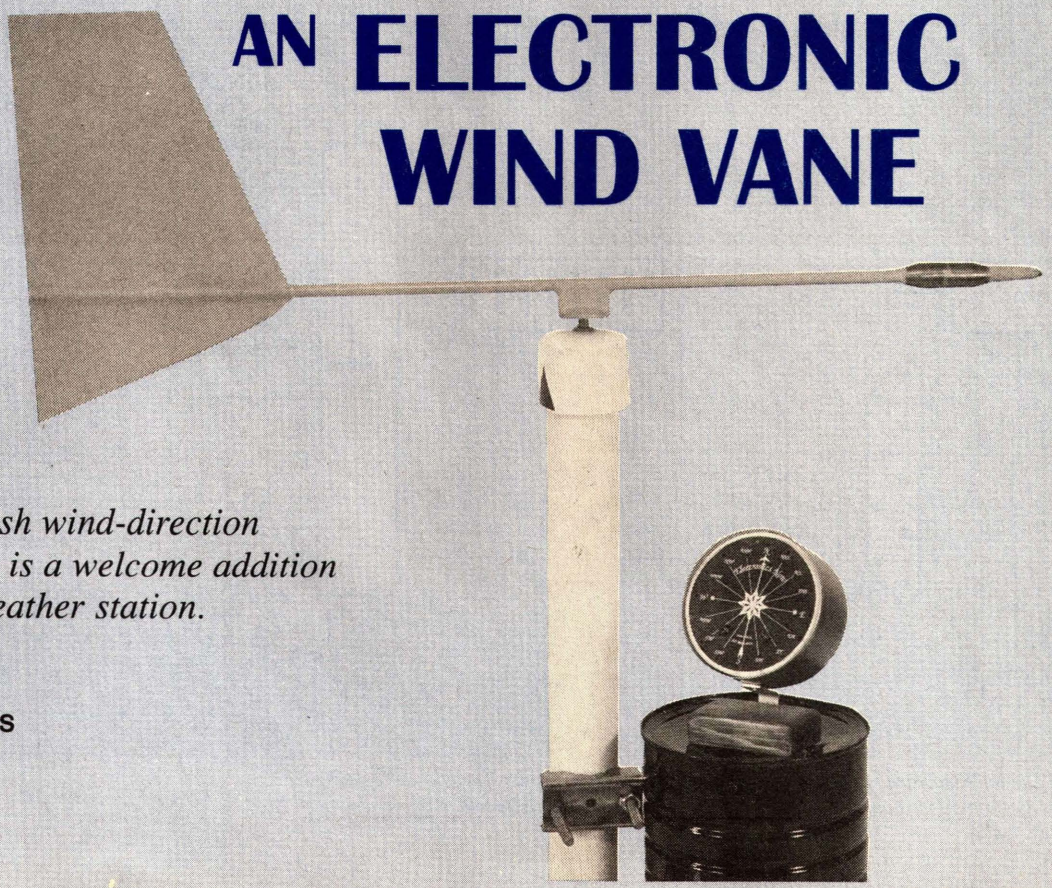
Calibrating and Using the Lightning Monitor. Tune a radio to the quietest spot that can be found on the AM band on a day with clear weather. It will probably be towards the higher end of the band—the lower end of the AM broadcast band tends to be more susceptible to terrestrially-generated EMI and RF interference. You might want to do that over a few

(Continued on page 47)

AN ELECTRONIC WIND VANE

This stylish wind-direction indicator is a welcome addition to any weather station.

STEVE BOTTS



Weather—probably one of the most talked-about subjects in the world. Increasingly, people are taking an interest in the unusual weather patterns that have been the subject of news reports over the past few years. Amateur weather-watchers are becoming aware of the importance of wind patterns. That group is not the only one—model-rocketry enthusiasts also want to keep track of wind direction before pressing the launch button.

Which ever way the wind blows... you'll know at a glance with the Digital Wind Vane project presented here. It is the perfect addition to a home weather station. A simple display lights up a light-emitting diode on a panel indicating the current direction of the wind. You can either build a wind vane for sensing the wind or modify an existing one to send its information to where it can be seen in the comfort of your home. No longer will you have to peer out of a window or go outside (especially in inclement weather) to take a reading of wind direction.

How It Works. As you can see from the schematic diagram shown in Fig. 1, the Digital Wind Vane is actually a simple circuit. The heart of the unit is IC1, a 4- to 16-line decoder chip. A 4-bit binary code applied to the input pins results in one of the 16 outputs being grounded. The outputs of IC1 are connected to the LEDs on the display. Since only one LED will be on at a time, R1 is a common current-limiting resistor for the display.

The inputs to IC1 come from ENC1, a rotary-shaft encoder that is attached to a wind vane outside. The wind vane works on simple aerodynamic principles that cause the "tail" of the pointer to have a greater drag causing the "head" to point into the wind. The length of the shaft and the area of the "tail" must produce enough force to rotate the shaft.

The rotary encoder that has been chosen for the Digital Wind Vane has two interesting properties. First of all, it is a "non-detented" type. That means that the encoder's shaft is free to spin any amount at a time with very little force needed to turn it—very much like a potentiometer. An encoder with detents, on the other hand, would act like a rotary switch, locking in place at a particular position. That type of encoder requires a greater amount of force to turn it, making it unsuitable for the Digital Wind Vane. The other unusual property of the encoder is that it does not have the "8-4-2-1" binary encoding one would expect from such a device.

If you write down a list of binary numbers in a column, you will quickly see that in several instances, more than one digit is changing between 0 and 1. Most notable are the changes between 3 (0011) and 4 (0100) as well as between 7 (0111) and 8 (1000). Because of variations in manufacturing, there is no guarantee that all of the individual digits will change at *exactly* the same time. For example, if the encoder is changing from 3 to 4, there might be a position of the shaft where the second and third bits have changed, but the first bit hasn't. The result would be 0101, or the binary equiva-

lent of 5. Obviously, counting from 3 to 4 by way of 5 is not an acceptable situation.

The rotary encoder specified in the Parts List produces a binary code called a "gray code." Table 1 shows the "gray code" generated by ENC1. If you study Table 1 carefully, you will notice that only one bit changes for each code change. That technique prevents the "out-of-sequence" problem that was detailed above.

The challenge in using a gray-code encoder now becomes getting the correct LED to light up. In the case of the Digital Wind Vane, the various LEDs are simply hooked up to the outputs of IC1 in the sequence needed to produce the correct display.

Building the Display. We'll start construction by building the display portion of the Digital Wind Vane. The layout of the circuit is not critical; using a perfboard with standard construction techniques will do just fine. However, if you want to keep the LEDs in a circular pattern, using a printed-circuit board would then be the best way to go. If you would like to use a PC board, a foil pattern has been included here. The unusual circular pattern of the PC board has been designed to fit an easily obtainable item that can be used as a case—details on that part of the construction will be discussed later.

The PC board is a single-sided design, making it easy to etch and drill your own. If you are using the foil pattern provided, follow the parts-placement diagram in Fig. 2.

It is easiest to assemble the components to the PC board in size order, starting with the several jumper wires that are needed. Although bare wire can be used, it is better to use insulated wire such as 30-gauge wire-wrap wire. That way, the longer jumpers won't bend and accidentally short.

Note that there are also two jumper wires labeled JP1 and JP2. Those jumpers are related to an additional feature of the Digital Wind Vane: In standard operation if there is no wind blowing, the unit will still indicate the direction that the wind was blowing before dying down. However, an optional signal can be applied to the unit from an anemometer—a device that measures wind speed. If that input (pin 4 of J1) is grounded, the Digital Wind Vane will indicate the direction of the wind. If the anemometer input goes high (no wind), then the Digital Wind Vane will go dark.

For now, install both jumpers; JP1 will be needed for testing the unit. If you have an anemometer with a suitable calm/wind indicator that is compatible with the Digital Wind Vane, you can remove JP1 after testing the unit. Of course, leaving JP1 in place after testing (for a continuous display) makes JP2 unnecessary. However, leaving that jumper in the circuit will not do any harm.

Check the orientation of each LED before installing it. Mount each LED so that its top is ½ inch above the board. As an option, you can use different colored LEDs for different compass points. One possible scheme would be to use green LEDs for the North, East, South, and West points. Red would be at the Northwest, Northeast, Southeast, and Southwest positions, with yellow LEDs at the other locations. The particular arrangement is up to you—using the same color all around is perfectly acceptable.

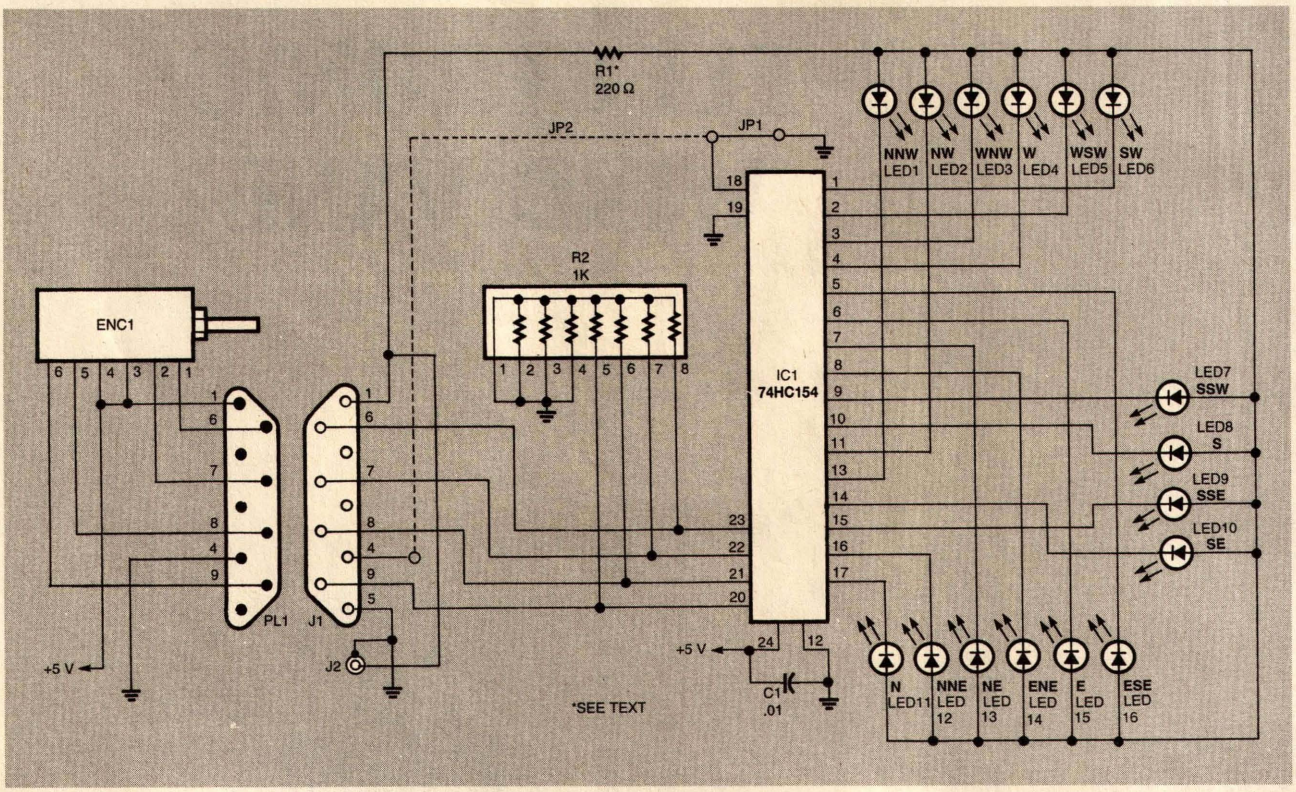


Fig. 1. The Digital Wind Vane is a simple circuit that uses a rotary encoder. The encoder's output is decoded by IC1 to light the appropriate LED. The connections of the LEDs reflect the code pattern generated by ENC1.

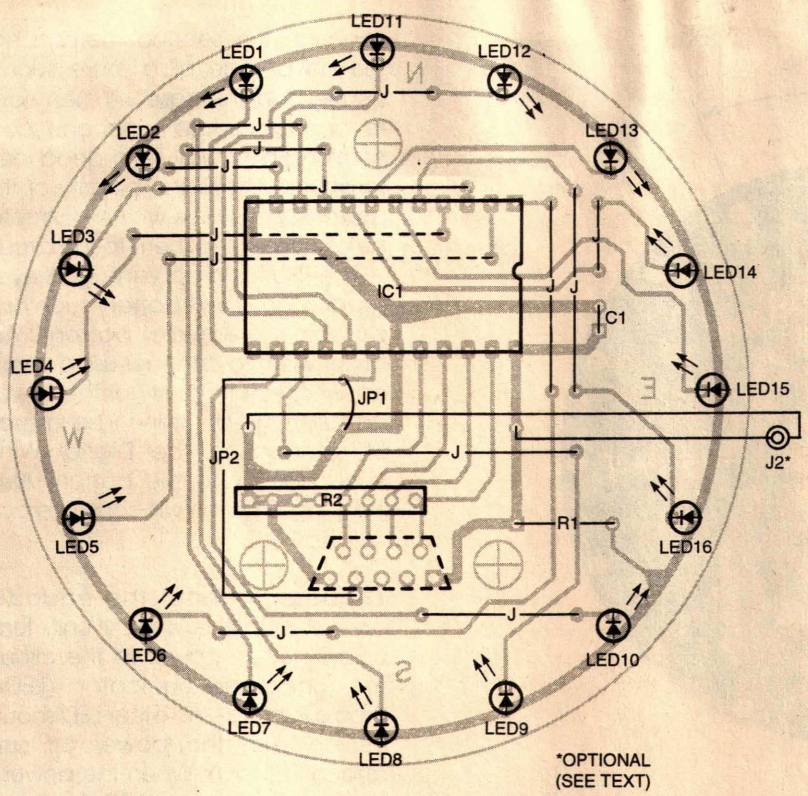


Fig. 2. Here is the parts-placement diagram for the Digital Wind Vane. The single-sided PC-board layout has several jumpers that need to be installed for the LEDs to work. Either JP1 or JP2 is installed if you are going to use the Digital Wind Vane with an anemometer that can signal if the wind is not blowing.

The value for R1 has been chosen for a 6-volt power supply. If you plan to use a 12-volt supply instead, you should increase the value of R1 to 1000 ohms. That will limit the LED current properly at the higher voltage.

Solder several short wires (about 1 inch long) to J1. Install J1 from the solder side of the board. Before soldering the wires to the board, use ½-inch threaded standoffs as temporary spacers to hold J1 off the board the correct distance. Carefully tack-solder the wires to the PC board, surface mount style, making sure that they don't touch each other.

Although IC1 can be soldered directly to the board, it is a good idea to use a socket. Not only will that protect IC1 from any static damage or overheating during soldering, it will also make replacing IC1 easier in case it fails in the future. Take care to install IC1 in the proper orientation. Also, that chip is a CMOS type, so observe all anti-static precautions when handling it. For example, you should always discharge both yourself and the PC board to a known ground point

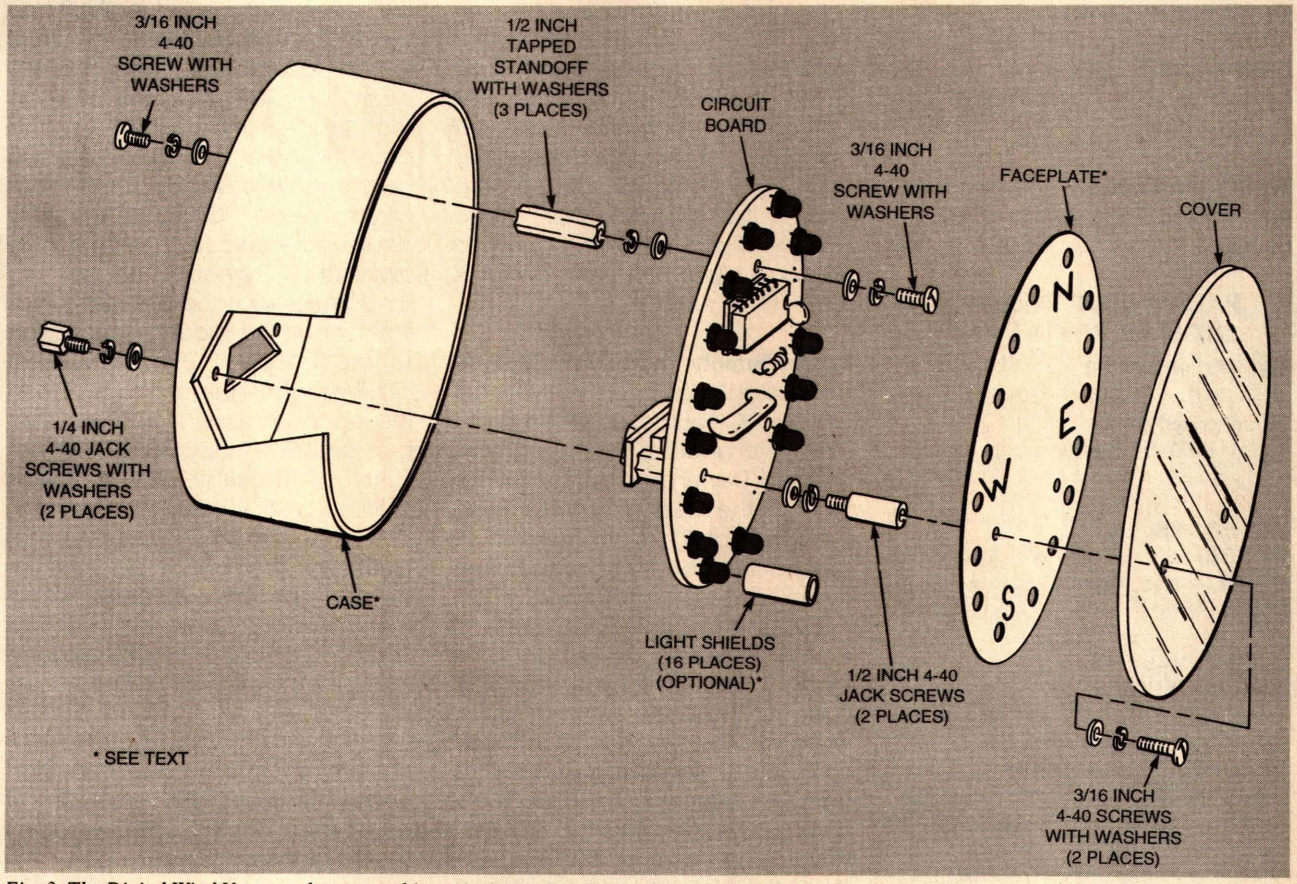


Fig. 3. The Digital Wind Vane can be mounted in an instrument cast to make an attractive display for a desk or wall. The case is an empty can of cat food or tuna fish that has been washed.

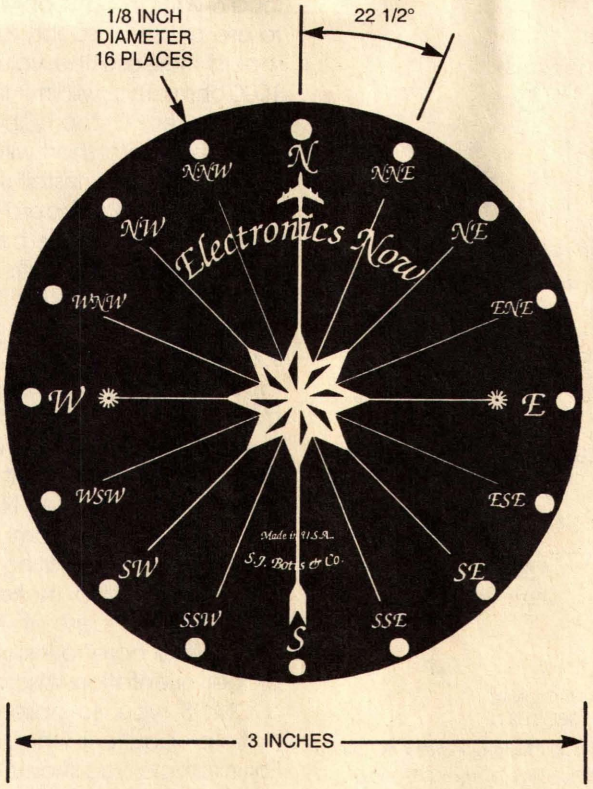


Fig. 4. This faceplate can be used as a pattern for the display. Feel free to design your own; the only requirement is that it match the case and LED pattern that you will be using.

before installing the chip. It is also best to try not to handle the chip by its pins.

Wiring the Encoder. The encoder is simply wired to PL1 as shown in Fig. 1. Because the circuit needs five wires between the encoder and the display, a five-conductor cable used for controlling antenna rotators will work well in this application. An added bonus for using that type of cable is that is designed for outdoor use. The Digital Wind Vane will work with a cable length up to about 30 feet.

Power Supply. The power supply for the Digital Wind Vane is not very critical—a DC source between 5 and 12 volts at about 200 mA is all that is needed. Depending on the voltage rating of the supply you will be using, the value of R1 might have to be modified in order to limit the current to the LED to about 20 mA.

Two options have been made for connecting the power supply to the Digital Wind Vane. One way is to connect the positive and negative wires from the supply to pins 1 and 5 on PL1. That way, a single connector handles everything needed by the display unit. Alternatively, provisions have been made on the PC-board foil pattern for separate power connections to the PC board directly. Although the second method has the advantage of a more secure connection, the case will then have to accommodate a second connection. Either way, it's a good idea to double-check the polarity of the power-supply wires with a voltmeter before attaching them to the circuit.

The Digital Wind Vane can even use a 6- or 12-volt battery such as a car or motorcycle battery. You might want to consider using a voltage-regulator circuit (for the 12-volt battery) and an in-line fuse instead of connecting the Digital Wind Vane directly to the battery. Also, installing a switch will conserve battery power.

Testing. Without the encoder attached to the display unit, temporarily apply power to the circuit. The Southwest indicator (LED6) should light up—no other LED should be on. Turn the power off and attach PL1 to J1. When the power is turned back on, one LED should be lit. The particular LED that is lit will be a random one—it depends completely on the current position of ENC1. Rotate the encoder shaft and see that each LED lights in turn. If there is a problem, check the PC board for cold-solder joints and correct placement of jumpers and parts. If IC1 was installed backwards or the power-supply connections are reversed, IC1 is most likely destroyed—replace it with a new one. If the LEDs seem to operate in a random fashion and are somewhat dim, check the ground connection to the encoder. Using a shorter cable length or larger gauge wire to the encoder should clear up that problem. If an individual LED will not light up, check to see if it was installed backwards.

Housing. The prototype was installed in a 3-inch-diameter "instrument case" as shown in Fig. 3. That "case" was eagerly provided by the family cat. If you don't happen to have an empty cat-food can, a tuna-fish can has the same dimensions. Wash and dry the can thoroughly. Removing the label almost completely hides the recycled nature of the enclosure.

Cut a hole in the back of the can for J1. An additional hole will be

PARTS LIST FOR THE DIGITAL WIND VANE

SEMICONDUCTORS

IC1—74HC154 4-to-16 decoder, integrated circuit
LED1–LED16—Light-emitting diode (see text)

RESISTORS

R1—220-ohm, ¼-watt, 5%
R2—1000-ohm, 7-element network (Digi-Key 4608X-10102-ND or similar)

ADDITIONAL PARTS AND MATERIALS

C1—0.01-µF, ceramic-disc capacitor
J1—9-pin male connector
PL1—9-pin female connector
ENC1—Rotary encoder, non-detented, 4-bit gray code (Digi-Key CT3003-ND or similar)
Wire, case, plastic mast pipe, pipe end cap, wood, brass, hardware, etc.

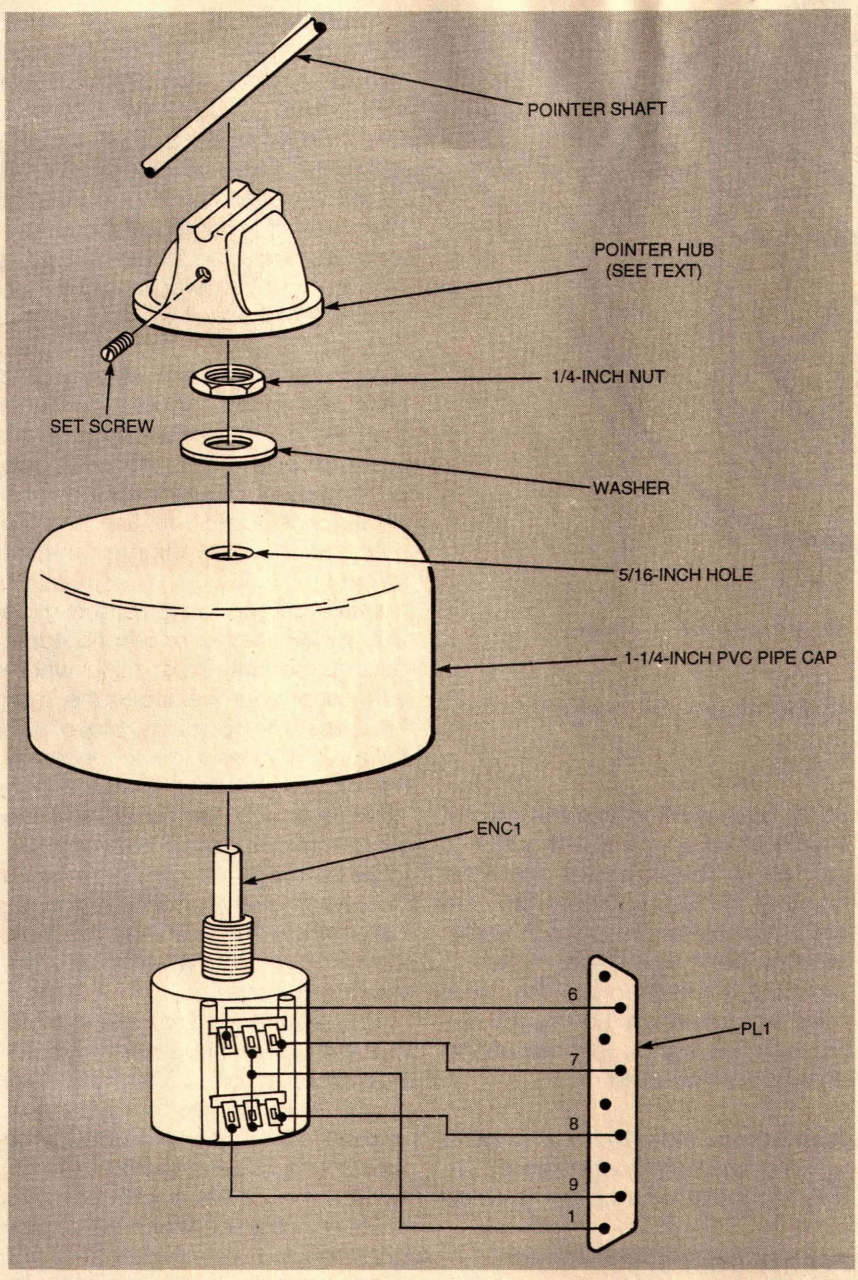


Fig. 5. The encoder for the Digital Wind Vane is mounted in an end cap for plastic pipe. The result is a low-cost, sturdy, and weatherproof housing.

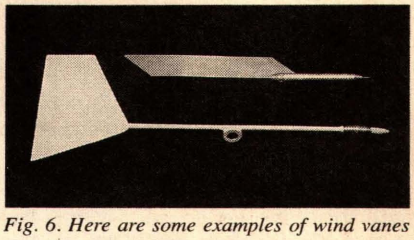


Fig. 6. Here are some examples of wind vanes that were built by the author. The tail of the larger wooden model can be cut from a square piece of thin plywood. The wooden version is glued to an equipment knob that can be clamped onto the shaft of ENC1. The smaller vane is made from brass shapes available at most hobby shops. Since it is made from metal, a simple hole and set screw at the balance point are all that are needed to mount it to the encoder shaft.

needed for a mounting screw. Mark the holes by placing the PC board in the can and tap it slightly to make an impression of the outline of J1. The metal in the can is very soft, making it easy to cut out a hole for J1. Install a standoff temporarily and tap the board as before to mark the mounting screw location. Drill three 1/8-inch diameter holes for the screws to pass through—one that was just marked and two at the sides of J1. One benefit of the choice of case material is that if you make a mistake, simply try again with a new can; the cat is sure to be willing to help out again!

Next, prepare a faceplate. The design can be as simple or as fancy as you want. An example that can be used if you lack the artistic flair is shown in Fig. 4. Glue the design to a piece of thin cardboard, such as a piece of paper plate. Use a 1/8-inch punch to cut clean holes through which the LEDs will shine. You might want to install light shields to concentrate and direct the LED light. You can use some red-colored plastic drinking straws or rubber tubing trimmed to appropriate lengths and slipped over each LED.

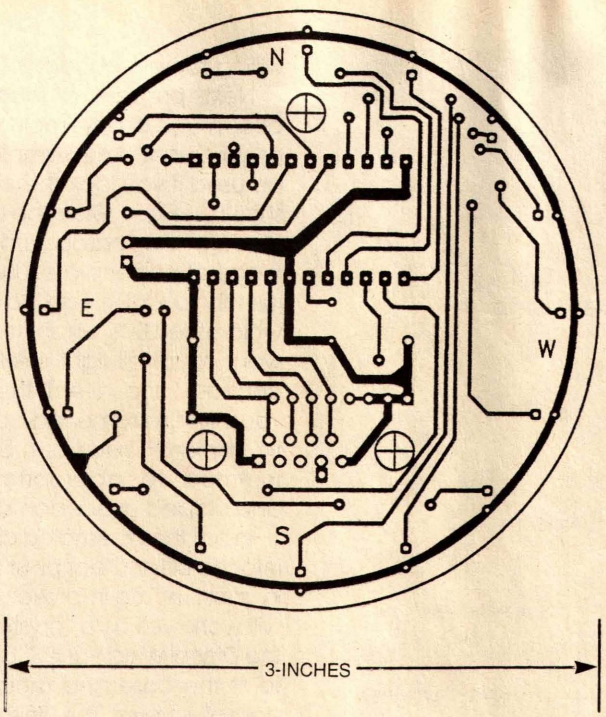
Install the assembled circuit board into the case. Clear plastic, available in most home-improvement stores, will work well as a "crystal" cover for the Digital Wind Vane. Cut the plastic to fit the case and mount it with a pair of screws. The finished display case either can be mounted in a larger case with other weather-forecasting instruments or a small stand can be made so that the display unit can be used on a desk or shelf.

Wind-Vane Construction. Personal taste will dictate the actual construction of the outside wind vane. You can either build your own or modify an existing device. In either case, a weatherproof housing will be needed for ENC1. Details are shown in Fig. 5.

The mast is a piece of 1¼-inch plastic pipe. That size is stiff enough to withstand strong winds. Drill a hole in the center of an end cap and mount ENC1 on the inside. Before mounting the encoder, pass it through the pipe. Once mounted, glue the end cap onto the pipe.

Examples of two different wind-vane designs built by the author are shown in Fig. 6. The larger one is made from a length of wooden dowel, some thin plywood, and a pair of hollow brass bullet-shaped fishing weights. The tail piece can be cut from a square piece of plywood. Before the fishing weights are soldered together, place some lead weights inside them. The various pieces are epoxied together.

A knob is used to attach the vane to the encoder shaft. Before epoxying it to the shaft, find the balance point of the vane. It should be able to sit on the knob without excess



Here's the foil pattern for the Digital Wind Vane. A single-sided layout makes the board much easier to etch for the home builder.

weight on either side. Once everything has been assembled, it can be painted any desired color.

The other vane is made from brass tube and sheet that has been soldered together. Again, it can be painted any color. An alternative is to polish the brass to a bright shine and coat it with a clear lacquer finish. If you want a "rustic" look, you can just let the brass weather; it will develop a greenish *patina* due to the copper content of the brass.

If you want to modify an existing vane, keep in mind that the pointer should be balanced; it should not be tail- or head-heavy. Also, the bearing in ENC1 should not be used to carry heavy loads. A better arrangement would be to use a ball-type thrust bearing. The wind vane would rest on the thrust bearing, which, in turn, would rest on the end cap of the mast.

Installation. Now that we have a working instrument and sensor, we need to install it and put it to work.

TABLE 1—ENCODER GRAY CODES

Position	A	B	C	D
1	1	1	1	1
2	1	1	0	1
3	1	0	0	1
4	1	0	1	1
5	1	0	1	0
6	1	0	0	0
7	1	1	0	0
8	1	1	1	0
9	0	1	1	0
10	0	1	0	0
11	0	0	0	0
12	0	0	1	0
13	0	0	1	1
14	0	0	0	1
15	0	1	0	1
16	0	1	1	1
	(1)	(1)	(1)	(1)

WARNING: USE CAUTION WHEN ERECTING THE WIND VANE. DO NOT INSTALL A MAST WHERE IT COULD COME INTO CONTACT WITH, OR FALL ONTO, POWER LINES. THAT COULD RESULT IN DEATH, SERIOUS INJURY, OR PROPERTY DAMAGE. A good rule of thumb is that a mast should be located twice the distance as it is high from any power lines. Also, be extra careful when working off the ground.

With no wind vane attached to ENC1, rotate the encoder shaft until the display indicates North. Mark the mast cap with a piece of tape or other mark. Mount the wind vane on the encoder shaft, line it up to the mark, and then tighten the set screw.

Install the mounting mast outside with a pipe clamp or other suitable arrangement. Keep in mind where you install your weathervane may influence the readings. Make sure that it is high enough to be away from any turbulence caused by other buildings. For example, if the wind vane is located between tow large buildings, it might only sense a "leeward" effect of wind channeling between the buildings. The main idea is to get the vane up into the prevailing winds.

Line up the mark on the mast so that it is pointing true North. A compass sighting on a distant object might help. When everything is aligned correctly, tighten down the mast clamps. Reconnect PL1 to J1, turn on the power, and check that the relationship between the display and the wind vane is correct.

Now that you have a working system, watch the behavior of the pointer. Ideally, it should not "hunt" (sway from side to side) in a steady breeze. Make sure that the fins and shaft are straight and true. You might need to adjust the wind vane itself in order to make it less sensitive. Sometimes, making the pointer's shaft shorter or decreasing the surface area of the fin will help. The fact that the pointer does not seem to respond to small breezes is OK unless it is binding or otherwise getting stuck. For weather prediction, we are interested in the prevailing winds that the vane will eventually line up with.

If you live in an area that is prone

to lightning, you should think about lightning protection. A direct lightning hit on the Digital Wind Vane will probably destroy everything from the encoder to the cable to the display unit. Be aware that even nearby lighting strikes could also damage the unit's electronics—particularly when using long cable runs. Pull-down resistor R2 gives some protection from static build-up. As an added precaution, connect the power supply's negative lead to a good earth ground.

Even if you are just adding an encoder to a wind vane that has been up for years, you now have a lead-in cable that will conduct lightning directly into your house. You should make sure that the mast is properly grounded or install a grounded lighting rod that is higher than the wind vane and mast. Another technique is to bend the input cable around some corners before it enters the house. Lighting usually will not take a corner as long as it has a straight ground path to follow. Furthermore, you can also use discharge tubes on each cable wire. Ω

LIGHTNING MONITOR

(continued from page 40)

days in order to get a good idea of how quiet the target frequency really is. AM broadcasts and interference often live a strange nomadic existence on the AM band.

Power up the Lightning Monitor and connect it to the speaker or headphone jack of the radio. Ideally, the radio should cut the speaker out when the Lightning Monitor is connected.

Set S2 to the "audio" position so that the radio can be heard through SPKR1. If a thunderstorm is in the vicinity, you should be hearing the static crashes from lightning strikes. If reception is good, you might even be able to hear them from thunderstorms that are many miles away. If a thunderstorm is not in the area, simulate one by using a hairdryer to create static or tune the radio to a strong station.

Set the radio's volume control so that the monitor gives a full-scale reading on the loudest of strikes.

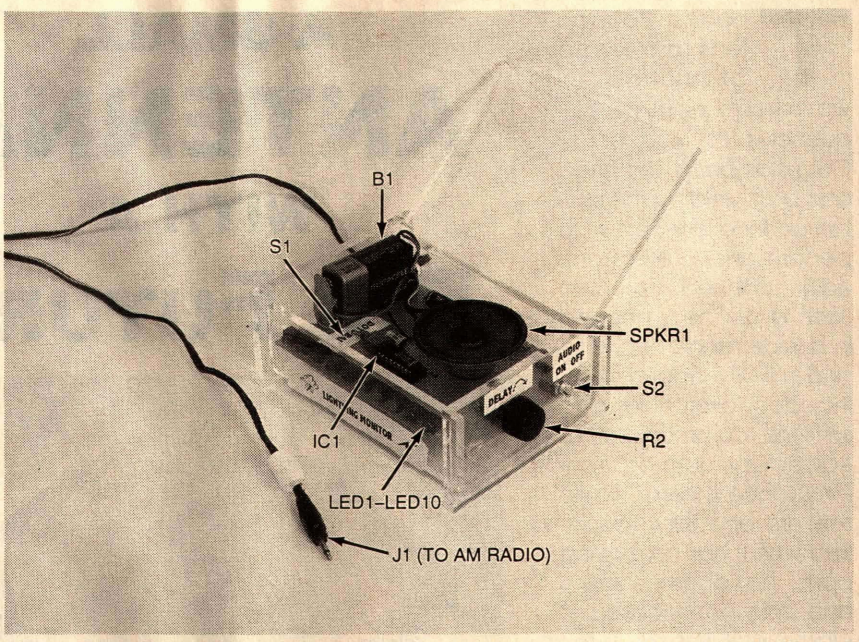


Fig. 2. The Lightning Monitor is simple enough to build on a perfboard. Here, the author's prototype has been mounted in a clear plastic case, making the Lightning Monitor both a decorative and a practical project. The battery can be replaced by a wall-mounted transformer for continuous use.

PARTS LIST FOR THE LIGHTNING MONITOR

SEMICONDUCTORS

IC1—LM3914N LED display driver, integrated circuit
D1—1N34A germanium diode
LED1–LED10—Light-emitting diodes (see text)

RESISTORS

(All resistors are ¼-watt, 5% units unless otherwise noted.)
R1—500-ohm
R2—1-megohm, potentiometer
R3—10,000-ohm
R4—10-ohm

CAPACITORS

C1—22-µF, 35-WVDC, electrolytic
C2—0.1-µF, Mylar

ADDITIONAL PARTS AND MATERIALS

B1—9-volt battery (see text)
S1, S2—Single-pole, double-throw switch
SPKR1—2-inch speaker
Case, knob, AM radio, hardware, etc.

Finally, set R2 so that the readings "fade out" inside a time interval that is reasonable for you to notice the event. A few seconds is usually sufficient. For continuous use, flip S2 to the other position and you will have peace and quiet again. If you begin to see readings on the LED display, flip S2 back to the "audio" position and listen to confirm that a storm is approaching—and not a local unlicenced "pirate" AM station.

If you live in an area where the standard AM broadcast band is too noisy, you might want to use a shortwave, marine, or CB radio. At frequencies over 15 MHz, terrestrial noise is less noticeable.

If you build the Lightning Monitor into a small box, you can also use it on days of clear weather as a portable "storage voltmeter" for measuring slow-changing low-voltage events such as temperature changes or light levels with a suitable sensor. Even if you don't happen to live in the "lightning capital of the world," it is always best to be prepared! Ω

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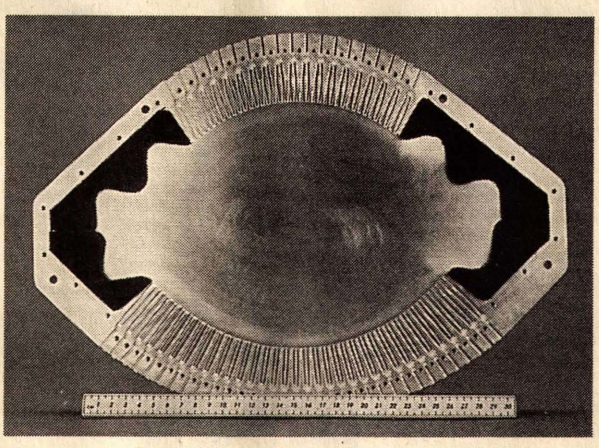
A SMALL ANTENNA WITH A BIG FUTURE



New technology has yielded a low-cost, high-reliability antenna that can operate at frequencies to 37 GHz.

DOUGLAS PAGE

The first Rotman lens to operate at millimeter-wave frequencies (*i.e.* frequencies as high as 37 GHz) has been designed and built, yielding the prototype for a low-cost, high performance, electronically scanned antenna. Such a device is needed in a wide range of civilian and military applications, including aircraft landing systems, communications equipment, auto collision-avoidance systems, missile seekers, and tank radars. Because it has no moving parts, no phase shifters, and can be encased in plastic, researchers at the Georgia Institute of Technology, where the device was designed and built, believe they have an inexpensive, rugged, reliable, and compact alternative to current millimeter-wave (MMW) antenna technologies.

"MMW components are compact and well suited for integration into missile-seeker heads, smart munitions, automobile collision- avoidance systems, and synthetic-vision systems," said Georgia Tech's Ekkehart (Otto) Rausch, senior research scientist. "In these applications, low-cost, rapid, inertialess scanning of the antenna is desirable. Most MMW antennas that operate at frequencies equal to or greater than 35 GHz use either a mechanical scanning approach or phase shifters for electronic steering. Phase shifters that operate at MMW frequencies are costly and introduce considerable RF loss. Mechanically steered antennas are relatively low in cost but are slow in response, sensitive to shock and vibration, and have moving parts that are subject to wear and failure. Thus, low-cost, high-reliability, and electronic scanning are generally incompatible unless the design is based on a MMW Rotman lens."

By avoiding those limitations, the new Rotman lens could open new applications for MMW radar.

How it Works. Rotman-lens devices get their names from their ability to focus microwave or millimeter-wave energy coming from a particular direction by passing this electromagnetic energy through a pair of lens-shaped parallel plates.

"This Rotman lens consists of a parallel plate region with waveguide ports distributed around the periphery of the plate," Rausch explains. "Beam-forming or focal ports are located on one side of the plates. Those ports are fed by a switch array. The array ports are on the opposite side, each connected to an antenna element. Energy, when input into a specific focal port, will emerge from the antenna elements and produce a beam along a particular direction. Switching the input from focal port to focal port will steer the beam electronically in one dimension. The concept may be extended to two dimensions by modifying the Rotman lens equations and generating two-dimensional surfaces for the focal and array contours."

Since the objective of the research was proof-of-concept, the design was restricted to one-dimensional scanning. Currently, the lens is constructed of aluminum. The potential exists, however, to build both the lens and the switch array using plastic. Production costs can be kept low by hot-pressing the antenna in plastic, which could then be coated with a conductor, such as gold. The antenna feed horns and switch arrays would be assembled the same way.

In addition to low cost, durability and compact size, another feature of the Rotman lens is the low throughput loss and sidelobe emissions. Sidelobe power in the prototype can be suppressed by a factor of one-thousand below the energy of the main beam. The lens itself loses less than 2 dB power.

"The antenna we are designing for Phase II of this project will have a gain in excess of 30 dB," said Rausch. "This antenna gain will be achieved with an array of 32 horn-antenna elements having a beamwidth of less than four degrees in azimuth and less than eight degrees in elevation."

In the past, Rotman, lenses were implemented with microstrip or stripline technology, usually between 6 and 18 GHz. Microstrips, however, are unreliable at high frequencies and are therefore not suitable for use in the millimeter-wave region. To reduce the losses to an acceptable value (between 1 and 2 dB), waveguides and air dielectric must be used between the parallel plates in the antenna.

Rausch and Andrew F. Peterson, of the Georgia Tech School of Electrical and Computer Engineering, fabricated the Rotman-lens MMW antenna out of a solid block of aluminum using designs that

Here, Georgia Tech's Otto Rausch attaches waveguides to test his Rotman-lens antenna.

specified tolerances of 0.0005 inches. A fabrication facility in New Jersey carved out the necessary shapes at those tolerances using an electrical-discharge method.

"Everything about this lens, from the width of the waveguides to the shape of the absorber foam, matters a great deal," Rausch said. "The surface roughness and even the placement of the screws all have been designed according to strict design principles."

Applications. Before the antenna can be successfully implemented in any of the potential application areas, Rausch anticipates expanding the antenna's operating frequency and adding the capability to scan in two dimensions. Once that has been successfully achieved, here are some of the ways that the technology could be used:

•Aircraft-Landing Systems. Heavy fog and other weather extremes can limit landing-strip visibility, preventing pilots from seeing the runway. A synthetic-vision system based on millimeter-wave radar technology could produce heads-up images through the fog, permitting safe landing in spite of difficult visibility.

•Automobile Collision-Avoidance Systems. Plastic-built MMW radar systems in automobiles could provide drivers with warnings of approaching vehicles. Plastic construction would keep costs low enough to make the systems economically practical.

•Commercial Communications. Rotman-lens antennas could be used in short-range, building-to-building wireless communication. Again, the use of plastic construction could lower the investment cost of such systems.

•Synthetic Vision for Assault vehicles. Operators of ground assault vehicles, such as tanks, also need fog and smoke vision aides, but harsh conditions and vehicle vibration limit the practicality of conventional antennas. A Rotman lens could be integrated into the tank's structure, eliminating the need for an external dish and providing durability and reliability.

•Missile Seekers. The Rotman-lens antenna's low cost, reliability, and small size could be ideal for use in airborne systems such as missile seekers. Ω

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ADD DAYTIME-RUNNING LIGHTS TO YOUR CAR

It's a simple matter to convert your current headlights to daytime-running lights with the addition of this easy-to-build circuit.

DAN HARRISON

Daytime-running lights (DRLs) are one of the newest safety features of modern cars. Many safety studies have shown repeatedly that having the headlights turned on at 80% of full brightness during daylight makes the vehicle—and its turn signals—more visible.

Available on European and Canadian automobiles for several years, DRLs are now being offered on cars sold in the U.S. market as well. One study of the safety feature of DRLs comes from an October 1991 report published by the Insurance Institute for Highway Safety of Arlington Virginia:

> "Keeping vehicle lights on to increase vehicle conspicuity during daytime hours has been found to reduce crashes in Scandinavia and the United States. Crashes of vehicles with and without daytime running lights owned by the Central Vehicle Agency of the Province of Saskatchewan were compared to a random selection of crashes drawn from provincial crash files involving vehicles without daytime running lights for the years 1982 through 1989. Daytime two-vehicle crashes involving vehicles approaching from the front or side were reduced by about 28% for the daytime-running-light equipped vehicles. A 28% reduction in daytime running light relevant daytime two-vehicle crashes corresponds to a 15% reduction in all daytime two-vehicle crashes."

If you have an older vehicle that does not have DRLs, then this project is probably the easiest way to add that safety feature to your car or truck. Not only is the DRL Adapter easy to install, it can be built for under $20—quite a small price to pay for protecting lives and property while driving.

How it Works. The DRL Adapter automatically turns on the low beams of the headlights at 80% of full intensity whenever the engine is running. The headlight switch is bypassed; however, it can always be used to override the DRL Adapter and turn on the headlights at full power. The partial intensity is achieved by supplying the headlights with an 80% duty-cycle-pulse waveform as shown in Fig. 1. As an added bonus, running the headlights with an 80%-duty-cycle waveform will not appreciably shorten the life of the headlight filaments. In fact, the service life of the headlights will be almost their normal lifespan.

Other adapters available on the open market rely on a delay timer. Once the ignition is turned to the "on" position, the DRLs come on after a 15-second delay. Some units simply turn on the headlights whenever the ignition is turned on. Those approaches mean that the headlights will be on—and draining the battery—if you have the ignition switch on without the engine running. That situation could occur if you were doing some troubleshooting on the vehicle's electrical system or simply listening to the radio while parked.

The DRL Adapter uses a novel method to prevent that situation from happening. A voltage-level-sensing circuit is included that prevents the DRL Adapter from turning on the headlights as long as the supply voltage is below 12.6 volts. Typical car batteries have a "stand-by" voltage between about 11.5 and 12.3 volts when fully charged. Only when the engine is running does the vehicle's charging system bring the electrical system voltage up to 13.3 volts or higher (usually above 14 volts). Since that only happens when the engine is running, the DRL Adapter will not turn on the headlights until the voltage at the battery rises above 12.6 volts.

The supply for the DRL Adapter is connected to a wire that only carries voltage when the ignition switch is in the "on" position. That way, the

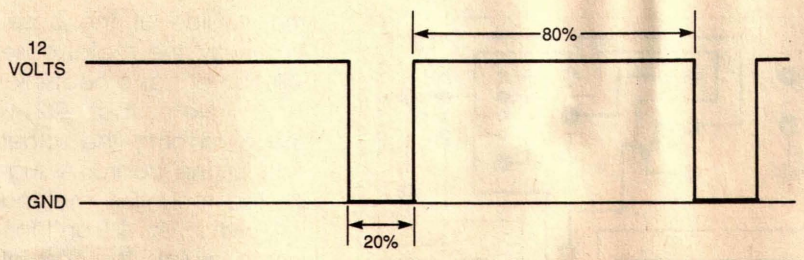


Fig. 1. Daytime-running lights (DRLs) work best when they are at 80% of full intensity. Supplying a standard headlight with an 80% duty-cycle pulse will not only dim the light to the needed intensity, it will do that without shortening the bulb's service life.

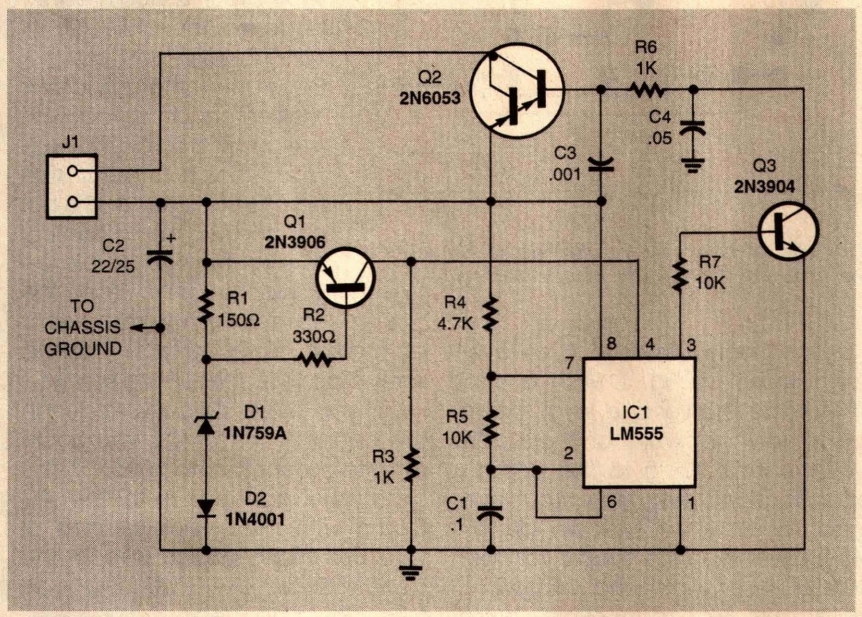


Fig. 2. The DRL Adapter is built around an LM555 that generates the 80% duty-cycle waveform. A Zener diode detects whether the engine is running or not by sensing the battery voltage. The DRL Adapter only turns the headlights on if the battery voltage rises above 12.6 volts.

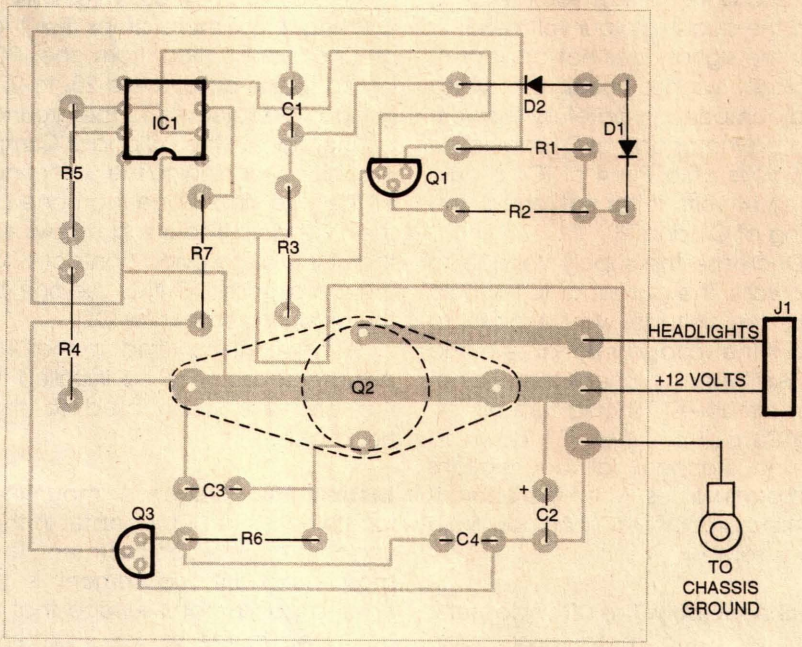


Fig. 3. Use this parts-placement diagram if you are building the DRL Adapter from a kit or from the foil pattern. Transistor Q2 is mounted from the solder side of the board.

headlights will not accidentally come on while the engine is being cranked, drawing precious current away from the starter motor.

Circuit Description. The schematic diagram for the DRL Adapter is shown in Fig. 2. The circuit is built around IC1, a 555 timer wired as an astable oscillator with an 80% duty cycle. When IC1 is running, the output on pin 3 looks like the output shown in Fig. 1.

The duty cycle of IC1 is set by the values of R4 and R5. When the output of IC1 is high, pin 7 is off, so R4 and R5 charge up C1. When the voltage level on C1 (and pins 2 and 6 of IC1) reaches the triggering voltage of IC1, the output goes low. Pin 7 is now grounded, discharging C1 through R5 only. The actual values shown for R4 and R5 result in a calculated duty cycle of 81%—so close that it would be difficult to see the difference between the intensity of a headlight driven at that ratio and one driven at a perfect 80% duty cycle.

The output of IC1 is inverted by Q3 so that the headlights will see the proper duty-cycle level. The inverted pulse train drives Q2, a PNP Darlington-type power transistor. When the output of IC1 is high, Q3 is turned on, grounding its collector terminal. That sinks current through the base terminal of Q2 and R6, turning on Q2 and applying power to the headlights.

The engine-start detector circuit is designed around D1 and D2. Combining the voltage drop of D2 with the Zener-breakdown voltage of D1 creates a total voltage drop of 12.6 volts. As long as the battery voltage is below that level, Q1 will remain off. The reset pin of IC1 will then be grounded through R3, disabling the oscillator. With the oscillator disabled, Q2 and Q3 will not turn on, so the headlights will not come on at 80% brightness.

Once the voltage applied to D1 rises above 12.6 volts, D1 conducts. That grounds the base of Q1, turning it on. The reset pin of IC1 then sees a positive voltage, and IC1 begins running, turning on the headlights.

Building the DRL Adapter. The circuit for the DRL Adapter is simple

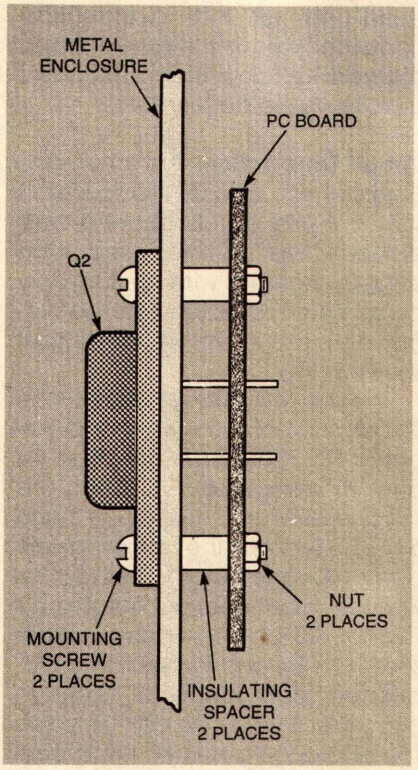
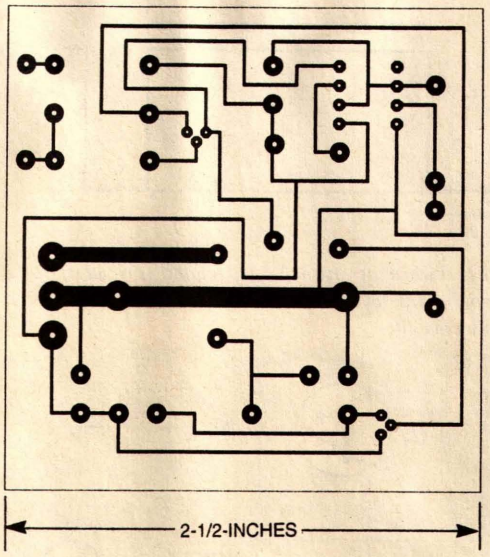


Fig. 4. Mounting Q2 on the outside of the case lets the case act as a heatsink. Not only should Q2 and its mounting screws be insulated from the case, the PC board should also be mounted away from the case to avoid short circuits.



Here's the foil pattern for the DRL Adapter. The circuit is simple enough to fit easily on a single-sided board.

enough to build on perfboard using standard construction techniques. As an alternative, you can design your own PC board by following the schematic diagram or use the foil pattern that has been included here. A pre-etched PC board as well as a kit of parts is also available from the source given in the Parts List. If you do use the foil pattern or purchase a board or kit, the parts-placement diagram in Fig. 3 indicates where the various components should be placed.

Mount all of the components on the board with the exception of Q2. Once all of the parts are soldered, double-check your work for any construction errors that might have occurred, such as miswiring or bad solder joints. Once you are satisfied with your work, it is time to test the board.

Testing. Connect a variable-voltage power supply to the 12-volt and ground inputs on the board. Turn on the power supply and set its output for 14 volts. With an oscilloscope, you should see a waveform on pin 3 of IC1 that looks similar to the waveform shown in Fig. 1. With a voltmeter, the DC voltage level should be somewhat lower than the supply voltage. According to the LM555's specification sheet, the output voltage on pin 3 will typically be 1.7 volts lower than the supply voltage. With a 14-volt supply, that will be 12.3 volts. An 80% duty-cycle pulse should give an apparent voltage of 9.84 volts. The actual reading you get will depend on the variations of the components that you are using and the quality of your voltmeter.

If the signal does not appear or is grossly wrong, check the wiring and components carefully. The voltage on the anode of D1 should be 12.6 volts ±0.6. Pin 4 of IC1 should be at 14 volts; if it is not, check the wiring of Q1 and R2.

Decrease the supply voltage to 12.6 volts. The output of IC1 should stop; the voltage will be close to zero. If the voltage is not at zero and IC1 is still running, check the engine-start circuit—Q1 should turn off, letting R3 pull pin 4 of IC1 down to ground. Recheck all connections and parts values. When the board is working properly, you can now finish the assembly.

Final Assembly. The DRL Adapter is mounted in a metal case large enough to hold the PC board. Drill suitable holes for the PC board, J1, and Q2, which will be mounted on the outside of the case. That way, the metal case will also act as a heatsink.

Note that Q2 is mounted onto the solder side of the board. A suggested mounting method is shown in Fig. 4. Don't forget to insulate the case of Q2 from the metal case that it's mounted on or a short circuit will be created between the collector of Q2 (12 volts) and ground. Be sure that the collector is making good contact with the circuit board. One way to do that is to use a star-type lockwasher and a nut on one of the mounting screws for Q2. Insulated standoffs that are the same length will be needed for both the PC-board mounting screws and Q2's mounting screws.

If you have difficulty soldering the connections for Q2, you could remote-mount the transistor on the case and connect it to the PC board with three short lengths of wire. Use heavy-gauge wire for the connections; at least 18-gauge wire should be used.

Jack J1 is wired as shown in Fig. 3. Use 16- or 18-gauge wires for the connections to the headlights and the 12-volt input—those wires will be carrying 10 or more amps. For the ground connection from the PC board to the case, use a 20- to 22-gauge wire soldered to the ground connection on the PC board. Crimp or solder a terminal to the other end of the wire and place it on one of the PC-board mounting screws so that it is making good contact with the metal case. DO NOT use one of the mounting screws for Q2!

With everything wired up, the DRL Adapter is ready to be installed in the car and connected to the headlights.

Installation. Select a mounting location for the DRL Adapter in the vehicle's engine compartment. The most important requirement is to have a good metal surface that is grounded to the vehicle's battery. You can always check that easily by measuring the resistance from the

(Continued on page 59)

USING CONSTANT-CURRENT SOURCES

Constant-current sources are easy to use, and can make other circuits work better. Here's how.

JOSEPH J. CARR

The constant-current source (CCS) is an overlooked circuit that has a lot of uses in its own right, and makes many other circuits work a lot better. A CCS is a circuit that will sink or source the same current regardless of changes in load resistance or power supply voltage. This article discusses several different types of constant-current sources, including the LM334 CCS diode, circuits based on JFET or bipolar transistors, circuits that use Burr-Brown's REF-series precision reference sources, and configuring three-terminal voltage regulator devices as constant current sources.

The Problem. So why is a constant-current source important? Although there is a very large array of applications for the CCS, the basic problem can be seen in Fig. 1A. The circuit shown there is a voltage divider (or, in instrumentation books, a half-bridge) in which one element (R2) is a thermistor—a resistor that changes resistance with changes in temperature. The output voltage, $+V_O$, is found from the standard voltage divider equation:

$$V_O = (V1 \times R2)/(R1+R2)$$

What that equation tells us is that the output voltage is a function of three factors, not just one. While we would like V_O to change only when R2 changes (which means that the temperature has changed), variations in source voltage V1 and the value of R1 also affects the output voltage. While we can regulate V1, and select a high precision, low temperature coefficient resistor for R1, there is another way.

That other way is shown in Fig. 1B. In this improved circuit, resistor R1 is replaced with a CCS. The output current, I_{OUT}, will remain constant even when V1 and the ambient temperature varies. The output voltage, *i.e.* the voltage appearing across R2, is simply the product $I_{OUT} \times$ R2. Other examples will be considered later when we look at a specific CCS device that you can buy very cheaply.

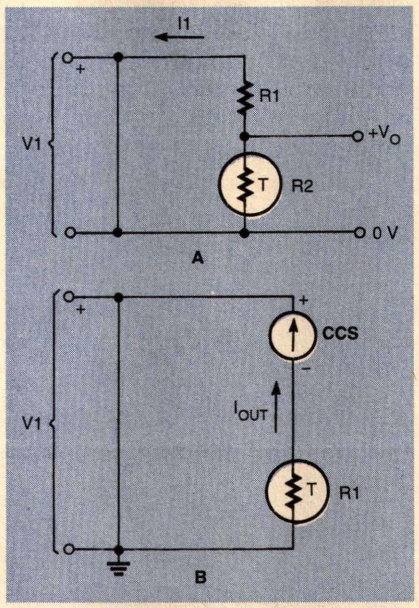


Fig. 1. The circuit in A is a classic half-bridge or voltage-divider circuit in which one element is a thermistor. In the circuit in B, the resistor has been replaced by a CCS.

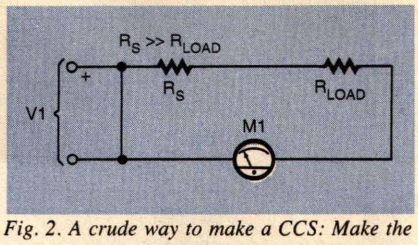


Fig. 2. A crude way to make a CCS: Make the source resistance very, very large compared to the load. Unfortunately, in practice this is usually an ineffective approach..

Constant-Current Source Circuits. The requirement for a CCS is that the output current does not change even if the ambient temperature, input voltage, and/or the load resistance changes. Figure 2 shows a crude and NOT recommended way of obtaining the CCS action. It does that by making the resistor (R_S) in series with the load (R_{LOAD}) very, very high relative to the load. Consider, for example, the case where V1 = 10 volts, R_S is 1,000,000 ohms, while R_{LOAD} varies from 0 to 200 ohms, with a nominal value of 100 ohms. When the load resistor is 0 ohms, the current flow is 10 V/1,000,000 ohms = 0.00001 A = 10 mA. When the load resistance rises to 100 ohms, the current is 10 V/1,000,100 = 0.000009999 A = 9.999 mA. And when the load resistance rises to 200 ohms, the current is 9.998 mA. Because the source resistance is so large compared with the load resistance, the range of current varies only from 9.998 to 10.00 mA, which is less than 0.02 percent change—constant for practical purposes.

There's only one little hitch to the approach of Fig. 2: currents higher than the microampere level require large voltages. If you need 1 mA, for example, a 1000 volt DC power supply is required for V1! There must be a better way.

Figure 3 shows one better way: use a pair of NPN bipolar transistors cross-connected to provide the constant-current action. That circuit uses a pair of MPS6523 devices, which can be replaced by NTE123AP or

ECG123AP devices. With the values shown, the constant output current (I_O) is approximately:

$$I_O = 0.6/R1$$

Or, with the value shown in Fig. 3 (100 ohms), I_O = 0.006 mA. Resistor R1 can be adjusted to provide the exact current required. I used this circuit several times and found that it would output currents from about 500 mA to 10 mA before falling apart and acting like something other than a CCS.

Another "better idea" is shown in Fig. 4. That circuit uses a diode-connected n-channel junction field-effect transistor (JFET) as a current-regulated diode (CRD) type of CCS. In that approach, the source and gate terminals are tied together to form the (-) electrode of the CCS, and the drain of the JFET forms the (+) electrode of the CCS.

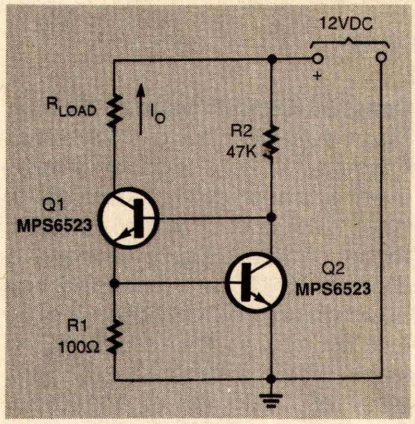


Fig. 3. A better approach is to use two cross-connected NPN bipolar transistors to create a CCS. Standard replacement devices (see text) can be used in place of the transistors shown if desired.

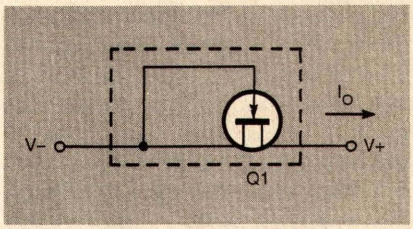


Fig. 4. A JFET can be used as shown to create a current-regulated-diode CCS.

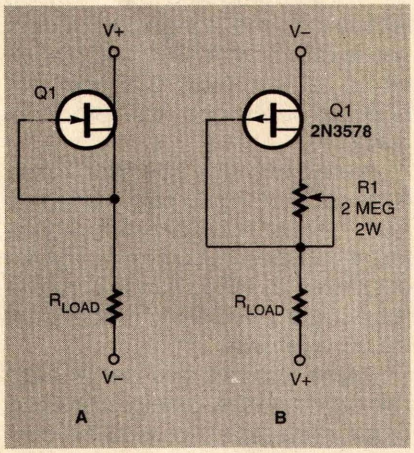


Fig. 5. One way to use the JFET CCS is to place it in series with the load (A). A variable set up is shown in B.

Figure 5 shows two ways that the CRD/CCS is connected into circuits. In Fig. 5A, the CRD is connected in series with the load, in a manner similar to the methods shown earlier. That makes good sense if the current created naturally by the CRD is what you need (or close enough to not matter much). A variable scheme is shown in Fig. 5B. That circuit is adjustable over the range 5 mA to 2 mA when a 2N3578 or its equivalent is used for Q1. Note that the JFET in this case is a p-channel device, so the polarity of the DC power supply, which should be greater than 18 volts in both examples, is reversed from the previous circuit. If you want to make a CCS for use with a positive power supply, experiment with n-channel JFETs with characteristics similar to the 2N3578 device. Note that the 2-megohm potentiometer (R1) is a 2-watt type, not the usual 0.5-watt types normally seen.

Another approach to creating a CCS that uses a positive power supply is the circuit shown in Fig. 6. That circuit uses a pair of 2N3368 (or equivalent) n-channel JFET devices cross-connected to form a CRD circuit. With the value of R1 shown, the circuit is adjustable over the range 200 nA to 1 mA. In experimenting with the circuit, I found that it worked better when Q1 and Q2 shared the same thermal environment, which means being very close together on the printed-circuit board. For best stability, one might want to bond the transistors together, or find a dual JFET that has approximately the same characteristics.

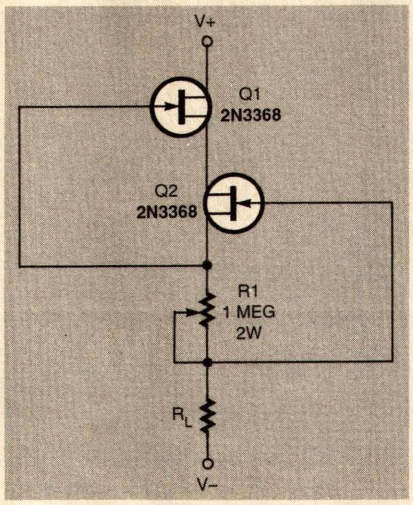


Fig. 6. This adjustable JFET-based CCS uses two transistors and a positive supply.

IC Current Regulators. In this age of integrated circuits, one would expect that someone would make a device for all purposes, and that's true of the CCS as well. There are several ways to use IC devices to provide constant currents to varying loads. One of the simplest is to use an ordinary 78xx, 78Lxx, 79xx, or 79Lxx three-terminal IC voltage regulator connected as shown in Fig. 7. In that circuit, a 78Lxx (members of the 78Lxx series are 100-mA versions of the 78xx devices) has a resistor (R1) connected between the ground and output terminals, to form a common output terminal to the load. The other end of the load is connected to the input voltage side of IC1 and the 0 V return line on the DC power supply. The output current is approximately $V_{RO}/R1$, where V_{RO} is set by the particular regulator (determined by the "xx" in the type number).

A better approach is to use a member of the REF series of precision voltage sources made by Burr-Brown. The pinouts for two of those

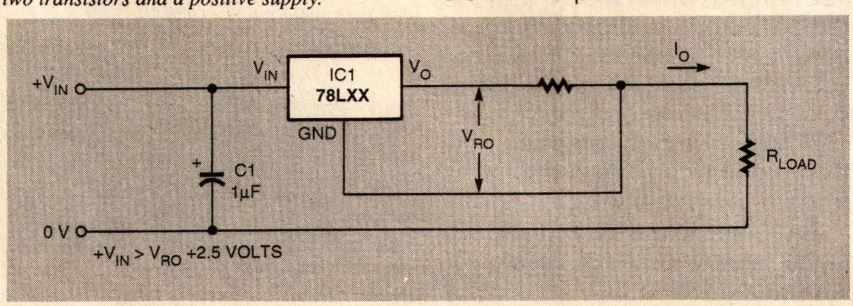


Fig. 7. Ordinary voltage regulators such as the 78Lxx can be used as a CCS when configured as shown here.

devices are shown in Fig. 8. The REF102 (Fig. 8A) is the replacement for the popular but recently discontinued REF01; it has a 10V output voltage (V_{OUT}). The REF02, shown in Fig. 8B has a 5-volt output and adds a TEMP output at pin 3. The voltage appearing at that output is scaled at 2.1 mV/°K, making it usable as a Celsius or Kelvin thermometer.

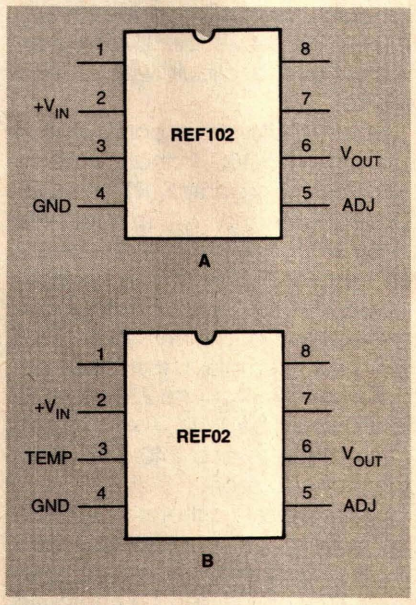


Fig. 8. Packages and pin-outs for the REF102 and REF02 precision voltage-reference ICs from Burr-Brown.

Figure 9A shows the REF102 connected with a positive power supply, while Fig. 9B shows the negative supply connection. The REF02 could also be used in the same circuit. With either device, the output current is:

$$I_O = (V/R1) + 1mA$$

Where: I_O is in mA, V is in volts and R1 is in ohms. The values for V are the values of output voltage for the particular device (V = 10 for the REF102 and V = 5 for REF02).

The LM334. One of the easiest CCS devices to use is the LM334. The device comes in both TO-22 metal and TO-92 plastic packages, although the commonly available form is the TO-92; a pinout of that package is shown in Fig. 10A. The LM334 operates over a very wide voltage range: 1 V to 40 V, keeping the current relatively stable over the entire range. With one external resistor (Fig. 10B), the LM334 device can produce a stability of 0.02%/V, with a temperature coefficient of 0.33%/°C and a set current range of 1 mA to 10 mA. The initial current accuracy is ±3%, but that can be trimmed.

The sense voltage used in the LM334 is proportional to the absolute temperature in degrees Kelvin (°K), *i.e.* 64 mV/°K, which are the same size as degrees Celsius (°C), but are referenced to absolute zero (≈273.2°C) rather than the freezing point of water. That means that an LM334 can be used as a temperature sensor of sorts (more on that later). The initial accuracy is not guaranteed, as in the LM335 temperature-sensor device, but it is good enough for many purposes and can be trimmed with an exter-

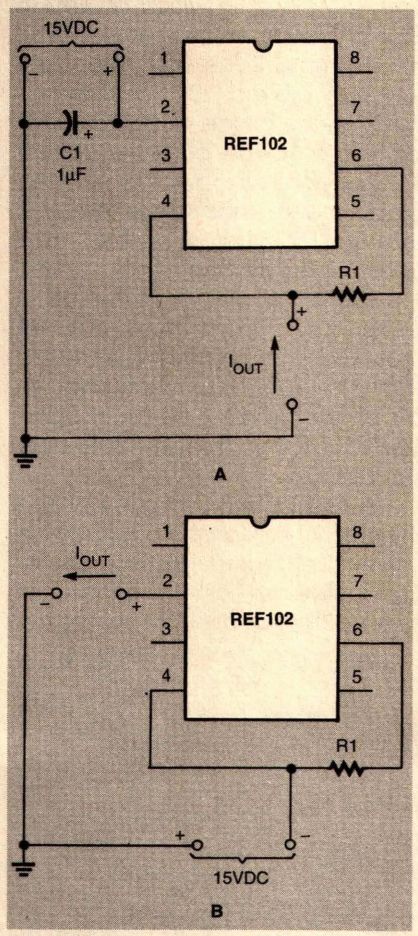


Fig. 9. Here are the circuits for using the REF102 (or REF02) as a current source (A) and sink (B).

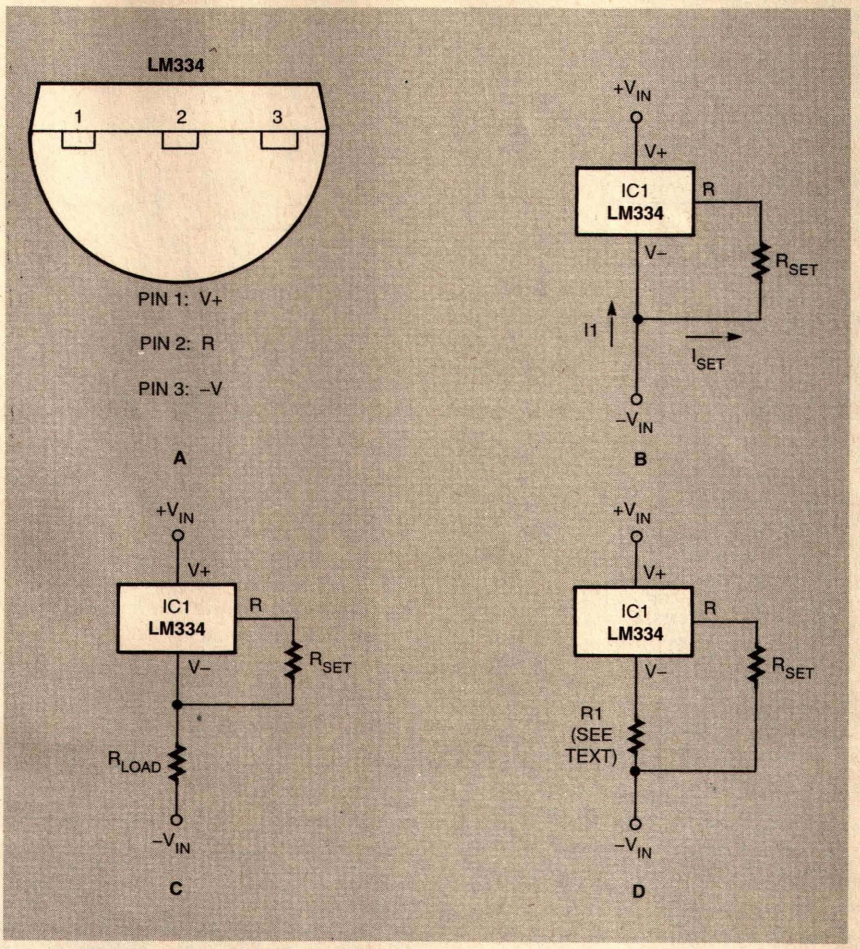


Fig. 10. The easiest to use CCS is the LM334. Its package and pinout are shown in A. A basic circuit is shown in B. The LM334 is shown connected in a circuit with a load resistor in C. An alternate circuit configuration is shown in D.

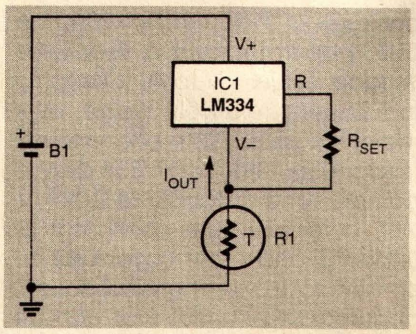


Fig. 11. The performance of the thermistor circuits in Fig. 1 can be improved by using the LM334 as the CCS.

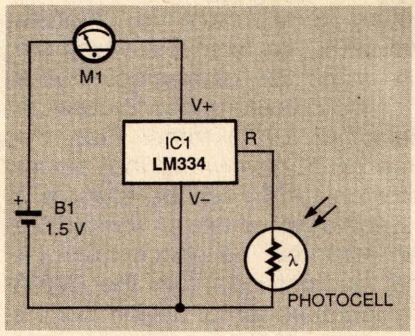


Fig. 12. Tthe LM334 is used here in a light-meter application.

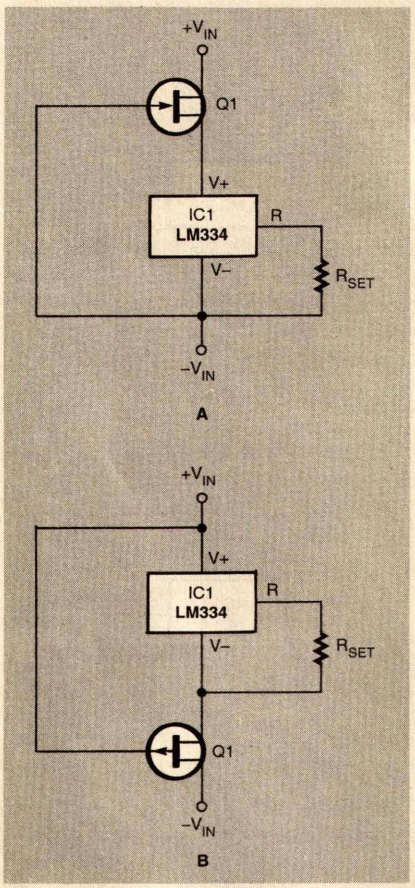


Fig. 13. In these circuits, an n-channel (A) and p-channel (B) JFET is used to reduce the circuit's distributed capacitance and make it look like a much higher source impedance to following circuits.

nal operational amplifier.

The value at the V- terminal current is a fixed ratio with the set current, I_{SET}, which ranges from I1 = 14 × I_{SET} to I1 = 16 × I_{SET}, depending on the current range and the particular device selected (use a nominal value of 15 for planning purposes). The set current is found from:

$$I_{SET} = 67.7\ mV/R_{SET}$$

For an R_{SET} of 220 ohms, for example, I_{SET} is 67.7/220 = 0.31 mA, so the output current is 15 × 0.31 mA = 4.65 mA. The value of R_{SET} can be adjusted to sort out differences caused by variation between devices, or the normal variation seen by current

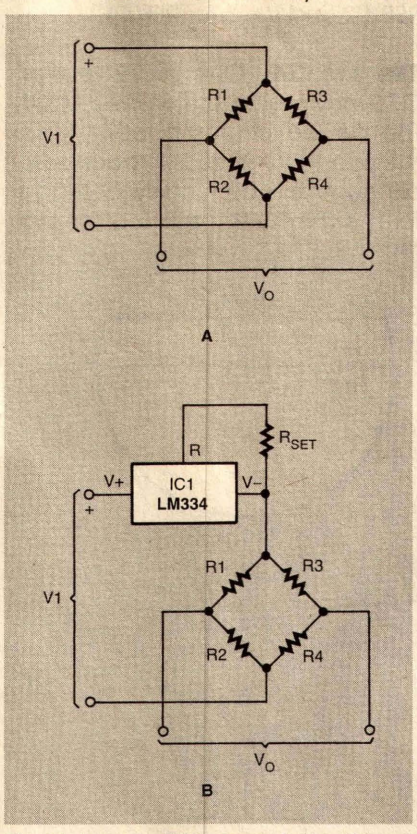


Fig. 14. A standard Wheatstone bridge (A), and one in a CCS configuration.

range. Once set, it will remain constant so long as R_{SET} doesn't change. That last requirement means that a low temperature-coefficient resistor is needed for R_{SET}. Figure 10C shows the LM334 connected into a circuit with a load resistor.

An alternate circuit configuration is shown in Fig. 10D. In that circuit an extra resistor is added (R1) in addition to the normal R_{SET}. To make the circuit work, select R_{SET} to be about ten percent higher than is normally needed for the level of output current required, and then make R1 = 3 × R_{SET}. For example, in the circuit discussed above, R_{SET} was 220 ohms, so here it would be $1.1R_{SET}$ = (1.1)(220) = 242 ohms (use a 240-ohm standard value resistor).

Earlier we saw a thermometer circuit in which a thermistor was used as the temperature-sensing element. That circuit can be improved by using a CCS in place of one resistor (as was shown). In Fig. 11, we see a simple circuit in which an LM334 CCS is used to provide the current. For example, if the thermistor resistance is around 10K (a common value) in the middle of the range of interest, a 10 mA constant current would yield a voltage of 100 mV. The problem with that simple circuit is that the LM334 must be kept at a constant temperature. That normally presents little problem if the LM334 is inside an equipment cabinet mounted on a printed circuit board with other circuitry. Enough heat will be generated after the circuit stabilizes to result in a reasonably constant circuit.

Figure 12 shows a circuit for using the LM334 with a photoconductive cell in a light meter circuit. A photoconductive cell has a resistance that is a function of the light shining on

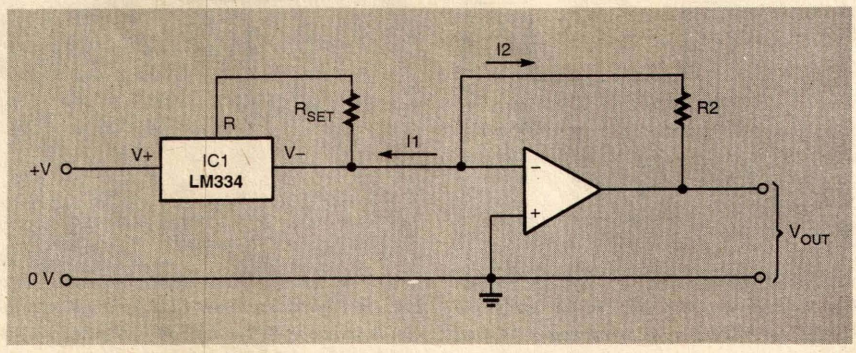


Fig. 15. A CCS can be used with an op-amp to produce output voltage.

the active surface: increase the light and the resistance drops. If a photocell is selected in which the resistance range is compatible with the required R_{SET} range, then the photocell can be used in place of R_{SET}.

Figure 13 shows two additional ways of using the LM334. In those circuits, either an n-channel (Fig. 13A) or p-channel (Fig. 13B) JFET device is used in series with the LM334. Because there is a voltage drop across the JFET in each of those circuits, the JFET and operating voltage must be selected to ensure that the voltage drop across the LM334 is at least 1 volt, and not more than 40 volts. With the JFET/LM334 configurations shown, the effect is to reduce the distributed capacitance and to make the device look like a much higher source impedance to following circuits.

Figure 14 shows two ways to excite a Wheatstone bridge. In Fig. 14A, the bridge is excited by a voltage source, V1. That works well in most cases. An alternative method is to use the LM334 in series with the voltage source (Fig. 14B). The available current from the LM334 splits between the two paths through the bridge circuit. It is common practice to make all resistors equal, and then vary one or more resistors in response to an external stimulus. For example, R1, R2, and R3 could be fixed resistors, while R4 could be a thermistor, photoconductive cell, or piezoresistive strain gage. The Wheatstone bridge is superior to the voltage divider method because the output voltage drops to zero when the stimulus is zero, assuming that the resting resistance of R4 causes the circuit to obey the ratio R1/R2 = R3/R4. The voltage drop across each resistor is a function of the constant current flowing in the circuit.

A final application for the LM334 (or any other CCS, for that matter) is shown in Fig. 15. In that circuit, the CCS is connected into the inverting input of an operational amplifier. The output voltage (V_{OUT}) is found from the product of I1 and R2, or I1 × R2. The output voltage will be constant so long as R2 is constant, but if R2 is a resistance-based sensor (*e.g.* thermistor, photoconductive cell, etc), then the output voltage is set by the change of resistance, which is in turn set by the applied stimulus.

Well, that about wraps things up. As you can see from this article, the constant-current source solves a lot of circuit problems, and is relatively easy to use. It is well worth learning about as it is the basis for a large collection of circuits used in instrumentation and other fields. Ω

DAYTIME RUNNING LIGHTS

(continued from page 52)

frame location to the battery's negative terminal; the resistance should be less than 2 ohms. Securely mount the DRL Adapter to the car.

Find a source of 12-volt power that can provide up to 15 amps of current and is only on when the ignition switch is in the "on" position. You can test the wire by carefully inserting a needle into the wire and measuring the voltage with a voltmeter while a helper switches the ignition on and off. Don't forget to check that the wire does not carry any current when the ignition switch is in the "accessory" position.

Use a wire splice to connect the 12-volt wire from the DRL Adapter to the switched 12-volt wire that you just found. Next, find a headlight connector that is easy to access and locate the wire that will power the low beams. That might not be as easy as it sounds. On some cars, high-beam/low-beam switching is done from the grounded side of the circuit. If that is your situation, connect the DRL Adapter to the common lead of the headlights. Splice the headlight wire from the DRL Adapter into that headlight wire.

Before routing and tying off the cables, test the DRL Adapter by turning on the ignition switch and making sure that the headlights do not turn on. Start the engine, and the headlights should come on at somewhat less than full brightness. That is easily tested by turning the headlights on and off with the motor running. When you turn the headlights on from the dashboard, they should come up to full intensity and return to 80% brightness when the headlight switch is turned off.

With everything tested and verified to be working properly, route the wires and tie them so that they will not rub against any sharp edges or touch any hot parts on the engine. With daytime-running lights, everyone will be safer. Ω

PARTS LIST FOR THE DAYTIME-RUNNING LIGHTS ADAPTER

SEMICONDUCTORS

IC1—LM555 bi-polar timer, integrated circuit
D1—1N759A Zener diode, 12-volt
D2—1N4001 silicon diode
Q1—2N3906, silicon transistor, PNP
Q2—2N6053, silicon transistor, PNP Darlington
Q3—2N3904, silicon transistor, NPN

RESISTORS

(All resistors are ¼-watt, 5% units.)
R1—150-ohm
R2—330-ohm
R3, R6—1000-ohm
R4—4700-ohm
R5, R7—10,000-ohm

CAPACITORS

C1—0.1-µF, ceramic-disc
C2—22-µF, 25-WVDC, electrolytic
C3—0.001-µF, ceramic-disc
C4—0.05-µF, ceramic-disc

ADDITIONAL PARTS AND MATERIALS

J1—2-pin connector
Case, wire, insulated standoffs, hardware, etc.

Note: The following items are available from: Harrison R&D, 9802 Sagequeen, Houston, TX 77089; Tel: 281-485-7107; e-mail: dharrison@ghgcorp.com: Kit of all parts including PC board, $30; PC board only, $7. Please include $3.50 for shipping and handling within US and Canada. Texas residents must add 6¼% sales tax.

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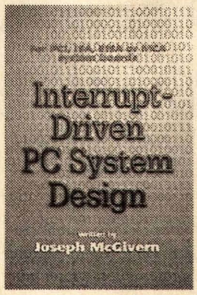

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This book is a complete overview of the issues needed to understand every aspect of the PC interrupt subsystem and how to get the most out of it. It is aimed at designers developing interrupt-driven-systems on an ISA, EISA-, MCA-, or PCI-based system board.

For example, PCI buses provide minimal support for interrupts. This book provides an easy-to-understand, insiders' angle on dealing with this and other problems. In addition, proven source and compiled "C" code samples give the designer a head start in real-world applications.

Beginning with the basics, the author covers the history and evolution of interrupt-driven systems, data synchronization, and the Intel 8529 Programmable Interrupt Controller (PIC), as well as the PC's master and slave PIC interrupt process. Following chapters cover controlling the interrupt process, interrupt service-routine structures and development, interrupt chaining-link design, and the 8529 PIC's Default IR7 features. Of special interest to PCI developers will be PCI interrupt processing hardware and PCI interrupt handling.

The last section includes application development and a series of valuable appendices with information on connector diagrams with call-outs, programmers' toolkit, PICMG 2.0 and PC/104+ interrupt binding specifications, PCI bios extensions, and software cross-reference.

Antennas With Wireless Applications

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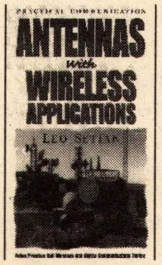

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Designed for technicians, engineers, or managers, this practical guide explains how to install, maintain, and optimize wireless antennas. Without advanced theory and mathematics, the book provides solutions to difficult wireless problems and makes coming up with answers fast and easy.

The author starts with a broad discussion of antennas, communication, transmission lines, and radiation. All the basic mathematics needed to work with antennas is covered, including complex numbers and phasors. Readers then learn about and model all three passive elements in an antenna circuit: resistors, capacitors, and inductors.

Subsequent chapters explain critical elements of antenna performance. Among the topics covered are: antenna impedance parameters, bandwidth and transformer-related issues, radiation resistance, electrical wavelengths, antenna patterns,

polarization, and wave propagation.

Using Smith charts to analyze and design antenna systems is explained in detail. There is a comparison of several state-of-the-art cellular radio antennas, as well as a discussion of signal processing and its implication for signal delivery.

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Centerville, OH 45459-4072
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Over 39,000 national brand-name items for the consumer-electronics repair, hobbyist, and service industries are included in MCM Electronics' latest catalog. Project accessories, semiconductors, connectors, test equipment, computer and home audio products, and OEM TV/VCR repair parts are some of the 5000 new products that have been added.

Among the manufacturers represented are Weller, Xcelite, Klein, Fluke, Hitachi, Sencore, Tektronix, Tenma, RCA, GE, Panasonic, ECG, Philips, Magnavox, Proscan, Quasar, Technics, Lexmark, Pioneer, Monster Cable, and Sony. A complete line of Denon replacement parts is being offered for the first time.

Bioelectronics Handbook: MOSFETs, Biosensors, & Neurons

by Massimo Grattarola and Giuseppe Massobrio
McGraw-Hill, Inc.
1221 Avenue of the Americas
New York, NY 10020
Tel: 800-2MCGRAW
Web: www.ee.mcgraw-hill.com
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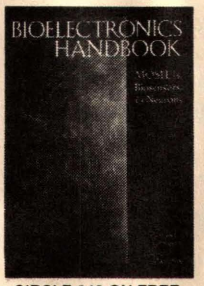

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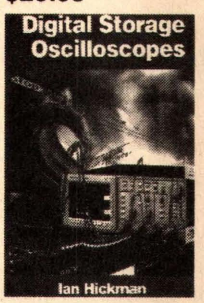
This book serves as a first introduction to the growing field of bioelectronics—the comparative study of phenomena and mechanisms in biology and electronics. It explains the analogies and differences between microelectronic technologies and natural systems. Designed for engineers, biologists, and biophysicists, the handbook covers everything from basic bioelectronic concepts to the development of neural chips to the building of biosensors and neural networks.

Models and simulations of electronic and bioelectronic devices are presented. The authors describe the materials, construction, and operations of hybrid bioelectronic devices. A thorough discussion of the Metal Oxide Semiconductor Field-Effect Transistor (MOSFET) is provided.

Digital Storage Oscilloscopes

by Ian Hickman
Newnes, Butterworth-Heinemann
225 Wildwood Avenue, Unit B
P.O. Box 4500
Woburn, MA 01801-2041
Tel: 800-366-2665 or 617-928-2500
Fax: 800-466-6520
e-mail: orders@bhusa.comom
Web: www.bh.com/newnes
$29.95



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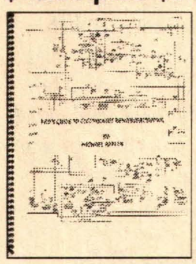
Digital storage oscilloscopes have long since supplanted analog storage oscilloscopes. They have reached a degree of sophistication and performance that enables them to rival the most advanced real-time oscilloscopes.

This comprehensive handbook provides a practical operating guide to the instrument for the engineer, as well as for students and trainees. The author describes how digital storage oscilloscopes work and explains how to use them to best advantage. Numerous charts and illustrations accompany each chapter. A guide to all makes and models is included.

Pro's Guide to Electronics Remanufacturing

by Michael A. Applen
Night Owl Publishing
4423 E. Mountain Sage Drive
Phoenix, AZ 85044
Tel: 602-753-5161
e-mail: CMWHISKERS@aol.com
$18.95 plus $3 S&H



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Electronics manufacturing processes have changed more and more rapidly. This pace will continue to increase well into the next millennium. Those changes have left open technology opportunities for entrepreneurs pursuing business that has high demand yet limited manufacturing capacity.

To fill the manufacturing gap, this book fully reviews the electronics components business plan for passive and active devices. A second business plan explains the custom data and power cabling business. Each plan takes the non-expert reader through the evaluation of component or custom cabling technology, components/cabling basics, business tools setup, and marketing and order fulfillment.

"Is This Thing On?"

by Gordon McComb
Prompt Publications
Howard W. Sams & Company
2647 Waterfront Parkway, East Drive
Indianapolis, IN 46214-2041
Tel: 800-428-7267 or 317-298-5400
Fax: 317-298-5604
Web: www.hwsams.com
$14.95

CIRCLE 345 ON FREE INFORMATION CARD

Written principally for those responsible for sound systems in churches, schools, city offices, hotels, and auditoriums, this book takes readers through everything from selecting components to installing, adjusting, and maintaining sound systems for such venues. The science of acoustics is discussed, including how sound is affected by an

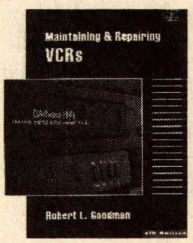
enclosed room and acoustic feedback.

It covers basic components of sound systems, sound-system specifications, and wiring sound systems, and reviews common sound-system terminology. In addition, procedures for installing wireless mikes, CD players, and portable public-address systems are detailed.

Filled with numerous drawings and illustrations, it explains in easy-to-understand terms the exact procedures behind connections and troubleshooting diagnostics. With the help of this book, hobbyists and technicians will be able to avoid the problems that often arise in setting up sound systems for events and lectures.

Maintaining & Repairing VCRs, 4th Edition

by Robert L. Goodman
Tab/McGraw-Hill
11 West 19th Street
New York, NY 10011
Tel: 800-2MCGRAW
$24.95



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If you're a technician, electronics hobbyist, or VCR owner with some technical aptitude, this practical manual will show you how to troubleshoot, pinpoint, and correct virtually every malfunction in VHS, Betamax, and 8mm VCRs. This edition has been completely updated to cover all the latest makes and models.

From snowy pictures to garbled audio, readers learn how to quickly fix such problems using the same techniques that the experts use. Step-by-step instructions and hundreds of photographs, pinout diagrams, and drawings make it simple to tackle even the most difficult repairs.

Packed with helpful case studies, this book contains invaluable information gathered from the service departments of companies such as General Electric, RCA, Panasonic, and Sony. Among the subjects covered in depth are mechanical systems and electronic circuits in VCRs, test equipment, servo and control systems, and camcorder and special VCR circuits. Handy troubleshooting flowcharts are included.

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Lumex Opto/Components, Inc.
290 E. Hellen Road
Palatine, IL 60067
Tel: 800-278-5666 or 847-359-2790
e-mail: sales@lumex.com
Web: www.lumex.com
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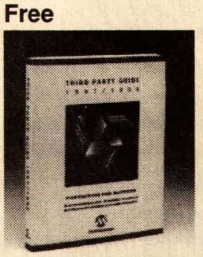
This 56-page catalog presents dot-matrix, graphics, and full-color TFT graphics modules, plus multi-digit LCD displays. Full electronic, mechanical, and application specifications, along with instructions for initialization and pattern coding, are included for the 39 standard products listed. External dimensions, display patterns, block diagrams, and pin connections are presented for the dot-matrix and graphic modules.

In addition, the catalog presents a wealth of technical data to help users understand how the various devices in the line function and to help determine their specific requirements for custom versions of the products.

Third Party Guide

Microchip Technology, Inc.
2355 West Chandler Blvd.
Chandler, AZ 85224-6199
Tel: 602-786-7668
Fax: 602-899-9210
Web: www.microchip.com
Free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Microchip Technology's fifth edition of its *Third Party Guide* is a comprehensive handbook that features third-party development support suppliers for Microchip's PIC micro family of 8-bit RISC-based microcontrollers, serial EEPROMs and related specialty memory products, and KEELOQ code-hopping devices.

The fifth edition features 130 companies worldwide who manufacture emulators, programmers, assemblers, simulators, linkers, compilers, software, and accessories that directly support Microchip's PICmicro microcontrollers and memory products. Among the companies represented in the handbook are: Advanced Transdata, BP Microsystems, Byte Craft Ltd., Data I/O, Hi-Tech Software, Logical Devices Inc., Microtek International, PROCHIPS Inc., RF Solutions Ltd., Tech-Tools, and System General.

In addition, the handbook contains a comprehensive listing of 183 worldwide design consultants who provide expert technical assistance for Microchip products. It is available through any authorized Microchip distributor or sales representative around the world.

Product Data Handbook and Applications Handbook

Unitrode
7 Continental Blvd.
Merrimack, NH 03054
Tel: 603-424-2410
Fax: 603-424-3460
Web: http://www.unitrode.com
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Unitrode Corporation has recently-published a *Databook* and *Applications Manual* featuring their broad selection of products. Unitrode is recognized as a world leader in the design and manufacture of high-performance, value-added, analog/ linear and mixed-signal ICs.

Both user-friendly books break down information into product sections and highlights. The 1200-page Databook provides datasheets on all Unitrode products, including general power supplies, portable products, hot swap managers, and intelligent motion controllers. The book starts with a complete part number index. Packaging and sales office information is also provided.

In addition, in 800 packed pages, the *Applications Manual* covers new products, application notes, and design notes. This publication starts with several useful indices. Application/design notes are indexed in several ways: by publication number, by product, and by subject. There is also an index listing related seminar topic abstracts and published papers by Unitrode authors. EN

BY DON LANCASTER

Buying Surplus Electronics, Class D Audio Amps, and More

THERE IS AN ABSOLUTE GLUT OF USED TEST EQUIPMENT AROUND THESE DAYS. ON THE "SUPPLY SIDE" OF THINGS, THAT'S BEEN LARGELY CAUSED BY AEROSPACE-INDUSTRY CUTBACKS, MILITARY REDUCTIONS, INDUSTRY DOWNSIZING, AND FROM community colleges dropping their electronics programs. On the "demand side," the cause is more and more use of simulation/emulation and of PC-based testing.

The good news is that you can now pick up first-rate lab equipment for a song. The bad news is that most of the old stuff is heavy, bulky, and possibly obsolete. Manuals might be missing or may cost more than the instrument. One or two key parts may be unobtainable at any price. Routine upgrades can make, say, a Tek 1240 logic analyzer worth a lot more than a 1230. Or an HP 4955 worth bunches more than a 4953. And getting a fair price when and if you sell is extremely tricky.

I've got a tutorial on surplus and auction sources for test equipment up on my Guru's Lair as RESBN73.PDF What I thought I'd do here is briefly run over the basics, and then take a more detailed look into how military-surplus electronic auctions have now gotten far easier to deal with.

Your simplest source with the best prices is right where it always was—at a nearby hamfest. There's extensive listings of those on the Web. Most parts of the country should average four local and two regional hamfests per year. The best bargains happen before sun-up or immediately before closing. And, yes, nonhams are welcome.

Naturally, you will find lots of ads for used test gear here in **Electronics Now.** Also check out our sister magazine, **Popular Electronics,** and similar technical magazines.

My favorite sources are the college auctions. Incredible buys are found, especially if you are willing to deal in unsorted ten skid and higher lots. If at all possible, try to catch these during the occasional "one-time" departmental closeouts.

At those, it also pays to know how to separate the junk from the gems. If you don't, here's an oversimplification that will at least help a little: Throw away gear that does not say Hewlett Packard or Tektronix on it, everything that's pre solid-state, and anything you can't easily lift.

I've found university auctions to not be nearly as good. First, because of hijacking from all the competing departments on tight or recently-cut budgets. Second, because your best stuff often gets set aside in a retail storefront. And third, because there's a lot more folks who haven't the foggiest clue of what they are bidding on.

One good regional source for information about all types of auctions is the fine *Southwest Auction Weekly.*

NEED HELP?

Phone or write all your US Tech Musings questions to:

Don Lancaster
Synergetics
Box 809-EN
Thatcher AZ, 85552
Tel: 520-428-4073

US email: don@tinaja.com
Web page: http://www.tinaja.com

Apparently the place to go for all electronic test goodies is Bentley's Auctioneer's in Albuquerque. Their shows tend to be held every second Friday and usually resell Sandia Labs stuff. By they way, here's an example of what I mean by glut: That last Bentley auction had fifty semi-loads of electronic gear for sale. All moved on out in a few hours for very low prices.

There are a bunch of direct-mail test-equipment outfits like Danbar, Tucker, Test Equipment Connection, Test Equity, Metric, and Naptech. All have useful catalogs. Although the asking prices are often outrageously higher than street, those "wish books" do clearly show you what is popular and what is not. Incidentally, you do get a bit extra in exchange for their higher prices. In particular, you usually get such things as full manuals, "like new" cleanliness, warranties, expertise, and someone to complain to.

Hint: Take a pile of these catalogs with you to each auction you attend. But be very subtle in their use.

These days though, there is no point whatsoever in messing around with those old Tektronix "doghouse" scopes, such as a 545. Go for a 2213 or a 2215 instead. The latter are ideal home-lab or student scopes. But if you are a collector or have racked up a lot of nostalgic time on one or more of the doghouses, then Stan Griffith's *Oscilloscopes: Restoring a Classic* is a must. More book details are found at www.tinaja.com/amlink01.html His volume on newer scopes is supposed to be in the works. Stan also knows of obscure parts sources.

I've tried to gather together a few used test-equipment resources for you in the sidebar. Lots of links to those and

new from
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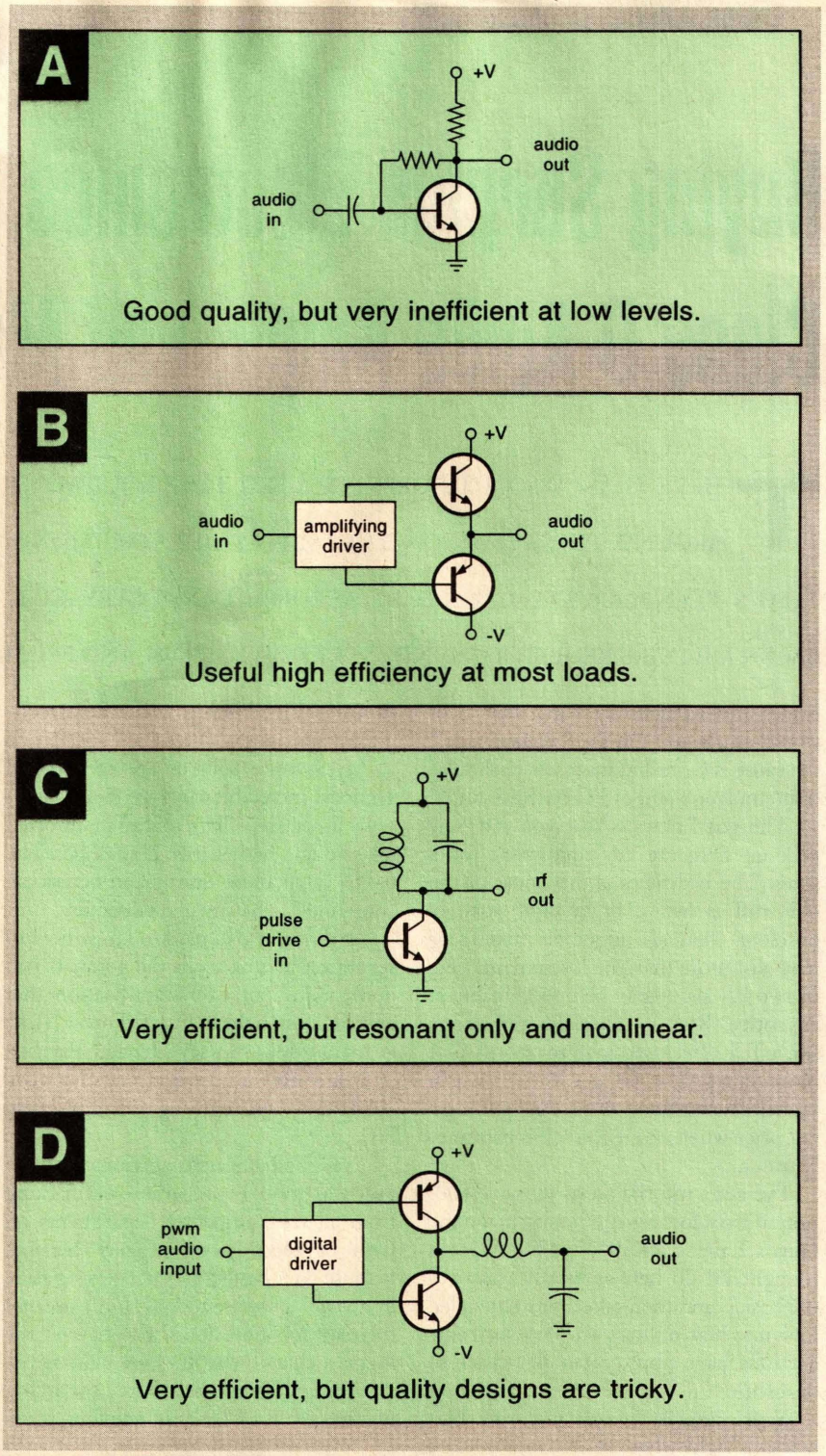


FIG. 1—THE FOUR CLASSES of audio amplifiers and their characteristics are shown here.

related sites can be found at www.tinaja.com/beewb01.html and www.tinaja.com/dntkwb01.html

By the way, by one of those utterly astounding coincidences that mysteriously seem to infest this column, I just happen to have some outstanding buys on Tek 2213 scopes and related goodies up at www.tinaja.com/barg01.html

Buying Military-Surplus Electronics

Quite a bit is coming down on this topic of late, so it's time for a review. On one hand, the fed's fresh www.drms.com Web site lets you conveniently submit bids online and later pay by Visa. The Web makes it ridiculously easier to search for items, to pick up bidder catalogs, and

to find out who bid how much for what. You can even find out who were the losing bidders. On the other hand, around half of the 140 or so DRMO (Defense Reutilization and Marketing Office) locations are going to shut down in the next few months due to downsizing.

There's several acronyms involved here. We've already looked at the local bases and locations called DMROs. The Web site and the service is called DRMS. Some sites also include an RCP, short for Recycling Control Point, that might specialize in bulk thousand-item LDV "low dollar value" sales of "winner takes all" assorted mechanical and electronics parts.

Let us review the bidding process you'd go through step by step. First and foremost, never bid on anything that you do not personally inspect! Second, be certain to have a definite plan as to how you are going to pick up and move the items, where you are going to store them, and exactly what you are going to do with them. Finally, never bid more than six cents on the dollar. Unless you just gotta have some item really bad. Also, be sure to factor in your travel costs and time on any buy.

Go to www.drms.com and click on Public Sales, then on Catalogs, then on Store Location. Scan all of the site locations to find out which bases you can reasonably access. Check the list every week or so, since not every site will get continuously listed.

There's several types of sales. The most common are your local sealed-bid sale and the national sealed-bid sale. In the latter, the offerings from widely separated sites are virtually collected together. The Net has now dimmed the distinction between the two. Local sales tend to have lower valued items in smaller quantities. Their catalogs are vastly easier to read. And an occasional gem is way more likely to be overlooked. A DRMO may also operate a real store with fixed prices, stage a local auction, or provide other options.

The Dynamic Catalog for any site is a brief inventory listing. Near the sale deadline, that gets expanded into their Official Catalog that has more details. Sadly, their official catalog may not always appear online. When it does not, you'll have to request a FAX copy instead.

At any rate, you usually scan the dynamic catalogs for nearby bases to see what crops up that you might find of interest. Then verify the additional details in their official catalog. The online bidding process is quite easy. Just fill in the blanks.

Use their powerful national search service to pin down the items being offered. Start with Category 6625 for most electronic test equipment. But watch out for Category 4510, because they are likely to throw in the "SINK, KITCHEN." Also use caution with any "APPROXIMATE QUANTITY: ONE" notations. Or any time that the term "RESIDUE" appears.

Getting onto the base to view the goodies or to pick up your successful bid items can be somewhat of a pain. Details vary with the site, but they go something like this: Near their main gate should be a visitor contact area. Your goal here is a day pass for you and your vehicle. They'll demand to see your driver's license, the vehicle registration, rental contract (if any), and proof of insurance. This should give you a magic piece of paper to gain base access.

Your key rules here are patience and politeness, combined with an acceptable appearance and demeanor. Also paying extreme attention to all details. A wrong turn can literally put you on a gunnery range or a bomber runway. The DRMO is often a fenced area in an obscure corner of the base. You'll usually park outside until you are specifically invited to move your vehicle to their exact pickup point. There'll be an office type of payment area and a separate pickup area. Visa, Mastercard, and certified check

USED TEST EQUIPMENT RESOURCES

Bentley Auctioneers
3801 Academy Pkwy. N NE
Albuquerque, NM 87109
(505) 344-1812

Danbar
14455-C N 79th St.
Scottsdale, AZ 85260
(602) 483-6202

Electronics Now
500 Bi-County Blvd.
Farmingdale, NY 11735
(516) 293-3000

Electronic Servicing
PO Box 12487
Overland Park, KS 66282
(913) 492-4857

Metric Equipment
3486 Investment Blvd.
Hayward, CA 94545
(800) 432-3424

Naptech
11270 Clayton Creek Rd.
Lower Lake, CA 95457
(800) 336-7723

Phelps Instruments
2631 Hillside Ave.
Norco, CA 91760
(909) 279-7347

Probe Master
215 Denny Way
El Cajon, CA 92020
(800) 772-1519

R&S Surplus
1050 E Cypress St.
Covina, CA 91724
(626) 967-0846

Southwest Auction Weekly
Box 61104
Phoenix, 85082
(602) 994-4512

Synergetics
Box 809
Thatcher, AZ 85552
(520) 428-4073

Test and Measurement World
275 Washington St.
Newton, MA 02158
(617) 558-4671

Test Equipment Conn
525 Technology Park
Lake Mary, FL 32746
(800) 615-8378

Test Equipment Plus
3331 W Bright Terrace
Tucson, AZ 85741
(520) 575-6967

TestEquity
2450 Turquoise Circle
Thousand Oaks, CA 91320
(800) 228-3457

Tucker
1717 Reserve St.
Garland, TX 75042
(800) 527-4642

ValueTronics
1925 S Wright Blvd.
Schaumburg, IL 60193
(800) 552-8258

Western Test Systems
530-C Compton St.
Broomfield, CO 80020
(303) 438-9662

NAMES AND NUMBERS

AMP
PO Box 3608
Harrisburg, PA 17105
(800) 522-6752

Analog Devices
PO Box 9106
Norwood, MA 02062
(781) 329-4700

Apex Microtechnology
5980 N Shannon Rd.
Tucson, AZ 85741
(520) 690-8600

Carousel News & Trader
87 Park Ave. W
Suite 206
Mansfield, OH 44902
(419) 529-4999

Contract Professional
125 Walnut St.
Watertown, MA 02172
(617) 926-5818

Dallas Semiconductor
4401 Beltwood Pkwy. S
Dallas, TX 75244
(972) 371-4000

Stan Griffiths
18955 SW Blanton
Aloha, OR 97007
(503) 649-0837

Harris Semiconductor
PO Box 17000
Memphis, TN 38187
(901) 682-0961

Hewlett-Packard
PO Box 10301
Palo Alto, CA 94303
(415) 857-1501

High Density Interconnect
525 Market St.
Suite 500
San Francisco, CA 94105
(415) 278-5242

Lindsay Publications
PO Box 538
Bradley, IL 60915
(815) 935-5353

Linfinity Microelectronics
11861 Western Ave.
Garden Grove, CA 92841
(800) LMI-7011

Micro Linear
2092 Concourse Dr.
San Jose, CA 95131
(408) 433-5200

Synergetics
Box 809
Thatcher, AZ 85552
(520) 428-4073

Tektronix
PO Box 500
Beaverton, OR 97077
(800) 835-9433

Texas Instruments
PO Box 809066
Dallas, TX 75380
(800) 336-5236

Time-Compression
203 N LaSalle St.
Suite 2100
Chicago, IL 60601
(312) 558-1548

Time Domain
6700 Odyssey Dr.
Hunstville, AL 35806
(256) 922-9229

Tra-Con
45 Wiggins Ave.
Bedford, MA 01730
(800) TRA-CON1

Tripath Technology
3900 Freedom Circle
Suite 200
Santa Clara, CA 95054
(408) 567-3000

are preferred. Cash seems to be accepted, but most personal checks over $25 are a no-no. Delivery is normally by way of a rk lift. Additional packing and loading is not provided. The one exception this is that LDV bulk sales will be l to you by truck.

singly, nothing special is needed r stuff off the base. Unless therwise, you simply drive n case, though, be sure to r paperwork, yourself, and her at all times. Especially if you happen to be towing an A-10 Warthog behind you.

Oh yeah, those WWII jeeps: Uh, military-surplus jeeps always get cut in half before they are sold, though these might make good bookends if you have a very large library.

Class "D" Audio Amplifiers

I just realized that it was over three decades since I last dealt with this topic—way back in *Electronics World* for February of 1966. I don't want to impetuously rush into an update, but after more than a few false starts, it finally seems like Class D audio just may be about to hit the big time.

The latest of laptops, wireless, and other new portable electronics all demand high-quality audio efficiently delivered from low supply voltages. The object of the game is to use the battery or supply energy only when and as it is needed to produce your desired sonic output. The holy grail is an audio amplifier that approaches 100% efficiency at all useful output levels, combined with speakers or other transducers that are as effective as possible.

Figure 1 shows the traditional audio-amplifier classes. The class A amplifier shown in Fig. 1A is usually biased to half of the supply voltage. The continuous current is high, doubling on audio valleys and going to zeros on peaks. The best efficiency you can hope to have approaches 50%, but that can happen only at full output. Thus, you will continuously draw power whether you need it or not. But class A audio quality typically has been the best you can get.

One older class B version is shown in Fig. 1B. Its NPN power transistor emitter follower provides positive load currents, while the PNP emitter follower takes care of the negative ones. Best efficiency can approach 76% and very little current is drawn at low signal levels. Typical Class B amplifiers introduce bad crossover distortion especially on the low-level signals. That can be gotten around by keeping both the transistors at least slightly conducting at all times; that class of operation is sometimes called Class AB.

The Class C amplifiers, like the one shown in Fig. 1C, are largely restricted to very narrow-band resonant uses, but easily can approach 100% efficiency. Narrow on-off impulses continuously "ring" a tank circuit, which converts the impulses into a continuous output. The transistor or whatever acts as a switch that is either on or off. The output level is set by the supply voltage, so it is much easier to frequency modulate such an amplifier than it is to change its output amplitude.

The class D amplifier of Fig. 1D is almost entirely digital. A pair of switches (often enhancement-mode power FETs) generate a very high-frequency, high-power pulse-width modulated square-wave by connecting a filter's input either to the positive or negative supply rail.

The usual switching frequencies are in the 100-kHz range. A low-pass filter averages out or integrates the duty cycle (or on-off time ratio) to generate the audio output. That, in theory, gives you high efficiency, good audio quality, and no crossover distortion.

To use any class D amplifier, your input audio first has to be converted into some ultrasonic pulse-width modulated waveform. That is easily and cheaply done using hardware or software. The deviation from a 50-50 duty cycle sets the instantaneous audio amplitude.

Figure 2 shows us how the low-pass filtered—or integrated—value of a pulse changes with duty cycle. While Fig. 3 shows us how the pulse width variations behave over the full audio-sinewave cycle.

One fun older example of class D operation happened on the Apple IIe, where software let you get more or less useful polyphonic audio from a speaker that was on-off driven.

Traditional problems with earlier class D amplifiers involved buzzing, distortion, switching losses, rather expensive magnetics, load matching, and power-supply sensitivity.

Some Examples

You should shortly be seeing great heaping bunches more on Class D amplifiers, possibly with exotic new names. For now, though, let's look at several of the main players:

Apex Technology—Among other products, their SA02 runs at 250 kHz and delivers up to 800 watts of output power. Their $295 unit is intended mostly for motor driving, magnetic bearings, and shaker table use. Their Web site is www.teamapex.com

Linfinity Microelectronics—They have a LX1720 controller/driver capable of delivering 35 watts of stereo audio. External power FETs are used to get 93% efficiency. Distortion is 0.08%. See www.linfinity.com

Harris—This company now has a new Class D Audio Amplifier Evaluation Board as their HIP4080AEVAL2, giving up to 200 watts of audio output at 94% efficiency. Everything is on the card, the PWM converter, drivers, power FETs, plus a four pole Butterworth output filter. The amp is mono only. The web link is www.semi.harris.com

Tripath Technology—These folks claim "digital audio amplifiers which really sound great". A full product line ranges from their TAA1102 two-watt unit for multimedia computers up through the TA0104, a 1000-watt 2-channel device for theater use. See them on the Web at www.tripath.com

There's lots of others, but this sampling should give you a good starting point.

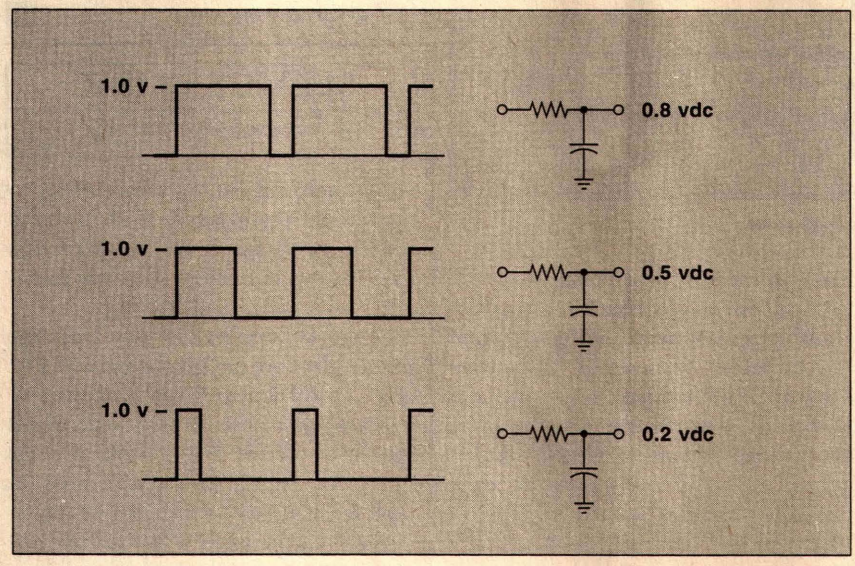


FIG. 2—THE DUTY CYCLE of "class D" pulse-width modulation (or PWM) determines the output amplitude you get after integration or low-pass filtering.

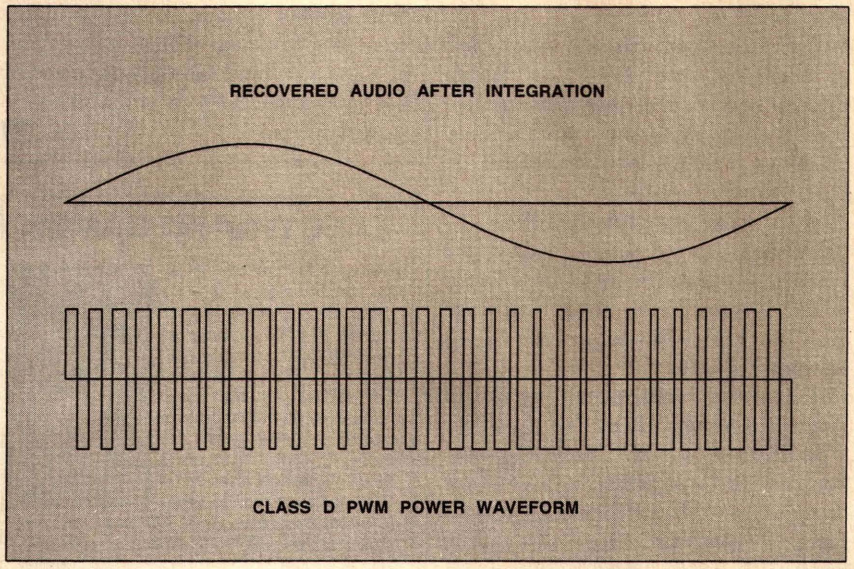


FIG. 3—HOW LOW-PASS FILTERING recovers an audio sinewave from its PWM waveform. The process is basically an integration.

More on Tesla Turbines

Several readers asked for some "real science" references to the Tesla turbines that we looked at back in MUSE124.PDF ("Tech Musings," June 1998). So, I've gathered a few of these together for your use in Fig. 4.

A Tesla turbine usually consists of bladeless disks, and operates through the shear forces of viscous liquids. Because those forces are inherently irreversible (or non-adiabatic) in a thermodynamic sense, Tesla turbines must be inefficient to work at all. So, that means that unavoidable waste heat must be kicked off regardless of whether you are in "pump" or "turbine" operating mode.

To me, the three things that seem to restrict Tesla pumps to extremely arcane and specialized applications (such as pumping frozen chickens or moving live fish), and to zero serious turbine and engine uses are: (A) the inherent inefficiency that is demanded by the required

Analytical and Experimental Investigation of Multiple Disk Pumps & Turbines, W. Rice, *Jnl of Eng Pwr*, July 63.

Analytical and Experimental investigation of Multiple Disk Turbines, W. Rice, *Jnl of Eng Pwr*, Jan 65.

Bulk Parameter Analysis for Two Phase Through Flow Between Parallel Rotating Disks, D. Jankowski *UC Davis Heat Transfer Procs*, June 1976.

Calculated Design Data for the Multiple Disk Turbine Using Incompressible Fluids, Laws & Rice, *Jnl of Fluids Engineering*, September 1974.

Design, Construction, and Investigation of a Tesla Turbine , A. Leaman, *University of Maryland* thesis, 1950.

Experimental Investigation of the Flow Between Co-Rotating Disks Adams & Rice, *Jnl Applied Mech*, September 1970.

Flow Regine Definition for Flow Between Corotating Disks, Crowther & Pater, *Jnl of Fluids Engineering*, March 1974.

Investigation and analysis of the Tesla turbine, S. Young, *University of Illinois* thesis, June 1957.

Investigations of the performance of a modified Tesla Turbine, J. Armstrong, *Georgia Institute of Technology* thesis, June 1952.

Potential flow between two Parallal Circular Disks with Partial Transmission, Matsch & Rice, *Jnl Applied Mech*, Mar 67.

FIG. 4—SOME "REAL SCIENCE" Tesla turbine resources.

thermodynamic reversibility violations; (B) the turbulent flow or otherwise lousy fluid dynamics at the inputs and outputs; and (C) all those experimenters who deify Tesla while not knowing enough math or having the faintest clue how to properly do decent research.

More on thermodynamic basics and on reversibility appeared back in HACK64.PDF (See my www.tinaja.com Web site). The apparent best use to date for the Tesla turbine seems to be for snowing thesis advisors.

New Tech Lit

Galileo's original lab notes have been posted to the www.mpiwg-berlin.mpg.de/Galileo_Prototype Web site. Two other rather interesting Web resources are www. sciencepostersorg/sposter-bin and www.uq.oz.au/nanoworld/gallery.html. Think small on this one.

Evaluation software for modeling signal integrity and communications lines is now provided on a freebie CD-ROM from Amp.

From Analog Devices comes details on a brand new AD7730 bridge transducer integrated circuit. This one uses a single chip to get you directly from a strain gauge or a pressure transducer to a useful digital output.

Details on a totally new Impulse Radio communications scheme are described in literature from Time Domain. A ten-mile range with 0.25 of a milliwatt is claimed. More info at www.time~domain.com

Buys on classic ethernet cards are available at www.tinaja.com/barg01.html

The latest of "new/old" titles from Lindsay Publications now includes *Elementary Wrought Iron* and the 1906, two-volume reprint of *Hopkin's Experimental Science*. More details at www.tinaja.com/amlink01.html

If you feel like you are stuck on a merry-go-round, check into the support group at *Carousel News and Trader*. They've got some great buys on wooden horses. The pony on a recent cover is a mere $82,000.

New trade journals for this month include *HDI*, short for High Density Interconnect; *Time-Compression* on rapid prototyping and on Santa Claus machines; and *Contract Professional* on independent consulting.

Free epoxy samples are offered by Tra-Con. Other free samples include the DS1620 digital thermometer from Dallas Semiconductor, and advanced high speed CMOS chips offered by the Texas Instruments folks.

For those fundamentals of digital integrated circuits, check into my classic *TTL Cookbook* and my *CMOS Cookbook*. You can get those either by themselves or as part of my bargain-priced *Lancaster Library* collection. See my nearby Synergetics ad for details. Or you can download the full online catalog at www.tinaja.com/synlib01.html

Latest of www.tinaja.com Web site additions include a lot of early "Blat" classics, including columns on patent avoidance and direct-toner printed circuits. There's also a cubic spline-length calculation and a sampler of magic-sinewave sequences. Finally, you'll find new links to all of those Book-on-demand service bureaus, and the great new InfoPack research service found at www.tinaja.com/info01.html

A reminder that most of the text-mentioned items appear in our "Names & Numbers" and "Used Test Equipment Resources" sidebars. Always look here before calling our free US technical helpline shown in the nearby box.

Let's hear from you. EN

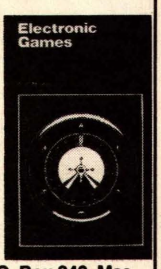
SERVICE CLINIC

continued from page 33

consistently off center with respect to the row of pits and lands. (With the servo loop open, the beam was crossing tracks more or less at random so it was sometimes centered!)

That's as far as we can take things this time, and we are not quite done with CD and CD-ROM players yet. Next time we will wrap up this series with some model specific problems and a look at some interesting signals you might want to explore if you have an oscilloscope at your disposal. In the interim, if you have any problems or questions that just can't wait, go to my Web site at www.repairfaq.org. Questions to me should be addressed via e-mail to sam@stdavids.picker.com. The finite number of hours in the typical day keeps me from answering mail via the postal service, but I will respond to e-mail in a timely manner, often within 24 hours. See you next time. EN

ELECTRONIC GAMES



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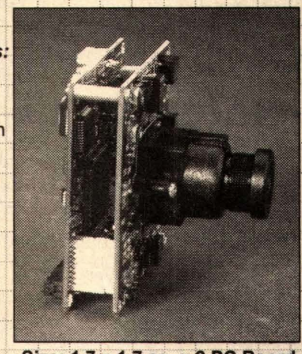

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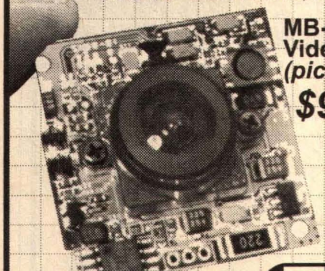

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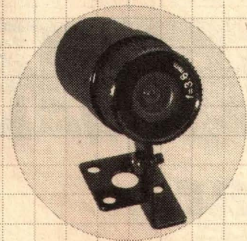

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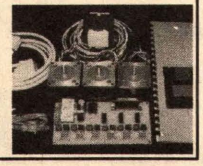

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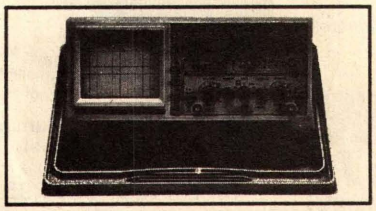

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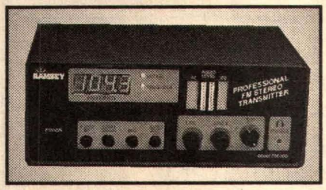

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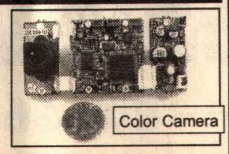
CCD Video Cameras

B&W Camera



Color Camera

If you're looking for a good quality CCD board camera, stop right here! Our cameras use top quality Japanese Class 'A' CCD arrays with over 440 line line resolution, not the off-spec arrays that are found on many other cameras. You see, the Japanese suppliers grade the CCDs at manufacture and some manufacturers end up with the off-grade chips due to either cost constraints or lack of buying 'clout'. Also, a new strain of CMOS single chip cameras are entering the market, those units have about 1/2 the resolution and draw over twice the current that these cameras do - don't be fooled! Our cameras have nice clean fields and excellent light sensitivity, you'll really see the difference, and if you want to see in the dark, the black & white models are super IR (Infra-Red) sensitive. Our IR-1 Illuminator kit is invisible to the human eye, but lights the scene like a flashlight at night! Color camera has Auto White Balance, Auto Gain, Back Light Compensation and DSP! Available with Wide-angle (80º) or super slim Pin-hole style lens. They run on 9 VDC and produce standard 1 volt p-p video. Add one of our transmitter units for wireless transmission to any TV set, or add our IB-1 Interface board for audio sound pick-up and super easy direct wire hook-up connection to any Video monitor, VCR or TV with video/audio input jacks. Cameras fully assembled, including pre-wired connector.

CCDWA-2, B&W CCD Camera, wide-angle lens.....$99.95
CCDPH-2, B&W CCD Camera, slim fit pin-hole len.....$99.95
CCDPH-2, Color CCD Camera, wide-angle lens.....$149.95
IR-1, IR Illuminator Kit for B&W cameras.....$24.95
IB-1, Interface Board Kit.....$24.95

FM Stereo Radio Transmitters

Microprocessor controlled for easy frequency programming using DIP switches, no drift, your signal is rock solid all the time - just like the commercial stations. Audio quality is excellent, connect to the line output of any CD player, tape deck or mike mixer and you're on-the-air. Foreign buyers will appreciate the high power output capability of the FM-25; many Caribbean folks use a single FM-25 to cover the whole island! New, improved, clean and hum-free runs on either 12 VDC or 120 VAC. Kit comes complete with case set, whip antenna, 120 VAC power adapter - easy one evening assembly.

FM-25, Synthesized FM Stereo Transmitter Kit.....$129.95

A lower cost alternative to our high performance transmitters. Offers great value, tunable over the 88-108 MHz FM broadcast band, plenty of power and our manual goes into great detail outlining aspects of antennas, transmitting range and the FCC rules and regulations. Connects to any cassette deck, CD player or mixer and you're on-the-air, you'll be amazed at the exceptional audio quality! Runs on internal 9V battery or external power from 5 to 15 VDC. Add our matching case and whip antenna set for a nice finished look.

FM-10A, Tunable FM Stereo Transmitter Kit.....$34.95
CFM, Matching Case and Antenna Set.....$14.95
AC12-5, 12 Volt DC Wall Plug Adapter.....$9.95

RF Power Booster

Add some serious muscle to your signal, boost power up to 1 watt over a frequency range of 100 KHz to over 1000 MHz! Use as a lab amp for signal generators, plus many foreign users employ the LPA-1 to boost the power of their FM Stereo transmitters, providing radio service through an entire town. Runs on 12 VDC. For a neat, professionally finished look, add the optional matching case set.

LPA-1, Power Booster Amplifier Kit.....$39.95
CLPA, Matching Case Set for LPA-1 Kit.....$14.95
LPA-1WT, Fully Wired LPA-1 with Case.....$99.95

Treasure Finder Kit

Search for buried treasure at the beach, backyard or park. This professional quality kit can detect metal at a depth of up to 6 inches. Easy to use, just listen for the change in tone as you 'sweep' the unit across the surface - the larger the tone change - the larger the object. Has built-in speaker or earphone connection, runs on standard 9 volt battery. Complete kit includes handsome case, rugged PVC handle assembly that 'breaks down' for easy transportation and shielded Faraday search coil. Easy one evening assembly. This nifty kit will literally pay for itself! That guy in the picture looks like he found something - what do you think it is - gold, silver, Rogaine, Viagra? You'll have fun with this kit.

TF-1, Treasure Finder Kit.....$39.95

Binocular Special

We came across these nice binoculars in an importers close-out deal. Not some cheap in-line lens jobs, these beauties have roof prisms, a super nice rubber armored housing over light weight aluminum. 10 x 25 power with fully coated optics. Includes lens cleaner cloth, neck lanyard and nice carry case. For extra demanding use in bright sun, choose the EX module with ruby coated Objective lens. First quality at a close-out price! We've seen the exact same units with the 'Bushnell' name on them being sold for $30 more!

BNO-1, Binoculars and case.....$24.95
BNO-1EX, Ruby Coated Lens Binoculars and case.....$29.95

Speech Descrambler

Decode all that gibberish! This is the popular descrambler / scrambler that you've read about in all the Scanner and Electronic magazines. Speech inversion technology is used, which is compatible with most cordless phones and many police department systems, hook it up to your scanner speaker terminals and you're in business. Easily configured for any use: mike, line level and speaker output/inputs are provided. Also communicate in total privacy over telephone or radio, full duplex operation - scramble and unscramble at the same time. Easy to build, all complex circuitry contained in new custom ASIC chip for clear, clean audio. Runs on 9 to 15VDC. Our matching case set adds a professional look to your kit.

SS-70A, Speech Descrambler/Scrambler Kit.....$39.95
CSS, Custom Matching Case and Knob Set.....$14.95
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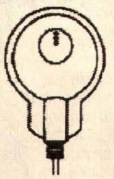
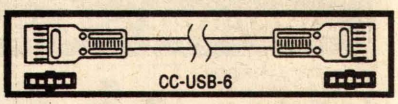


#TM-MIC-2 $1.00 each

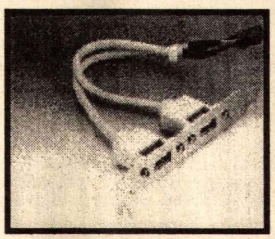
USB Cable

Male to male "A" to "A",



#CC-USB-6.....$5.00 each

USB Ports

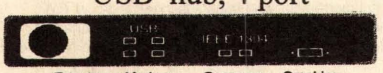


USB(2) to 10 pin motherboard w/ bracket

#TM-USB-9.....$7.00 each

Universal Serial Bus Hub

USB hub, 4 port



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#TM-USB-4HUB.....$79.00 each

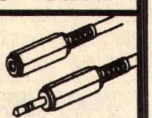
Mouse Pad

Sponge rubber backing to prevent sliding, many colors available, call for details.

#TM-PAD.....$1.00 each

Audio Cable

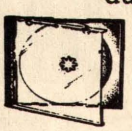
Stereo extension cables, for speakers and headphones3.5mm, male to female, shielded, 6 ft.



#AC-559.....$1.00 each

CD Jewel Case

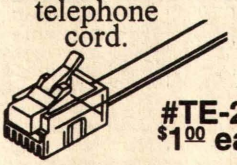
Replacement for original case. durable plastic.



#TM-CD-1 3/$1.00 each

Telephone Cable

25 ft. RJ-11 modular telephone cord.



#TE-254 $1.00 each

Stereo "Y"

3.5mm, one male to two females, great for connector two sets of speakers to one sound card.

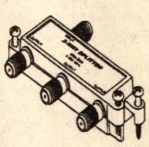
#AD-560 $1.00 each

BNC Coupler

BNC, female-female, for use with networks and video applications.

#AD-546.....2/$1.00

Signal Splitter



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Brass, M/F threads for mounting of motherboads, 10 piece bag.

#CN-471.....$1.00/bag

Mouse Pad

Sponge rubber backing to prevent sliding, many colors available, call for details.

#TM-PAD.....$1.00 each

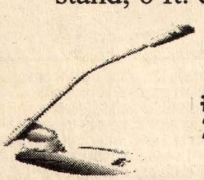
20' Audio Cable

Stereo extension cables, for speakers and headphones 3.5mm, gold plated male to female, shielded, 20 ft.

#AC-560.....$4.50 each

Multimedia Microphone

For soundcards and voice modems, microphone with stand, 6 ft. cord, gold plated 3.5 mm plug



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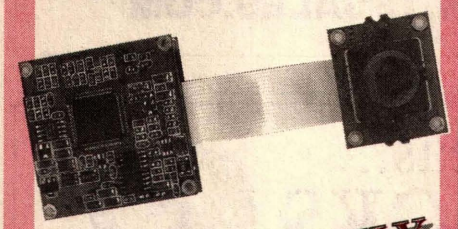

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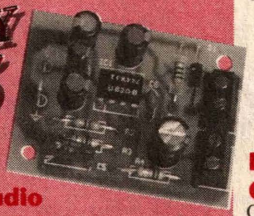

One Watt Audio Amplifier Module

Pre assembled circuit module is great for providing speaker level output in projects. Accepts line level input. Requires 4~14VDC, 250mA. Measures approximately 2" x 1½" x ¾". **Regular price $7.49**

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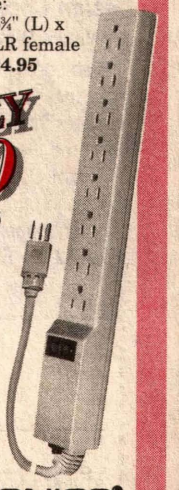

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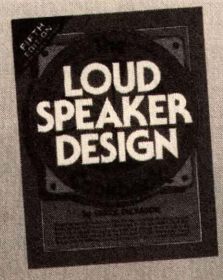

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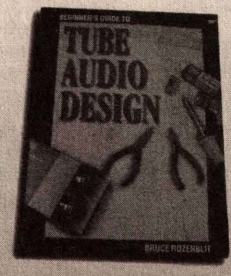

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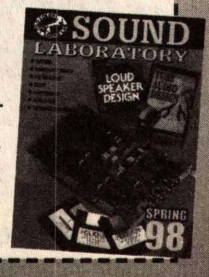

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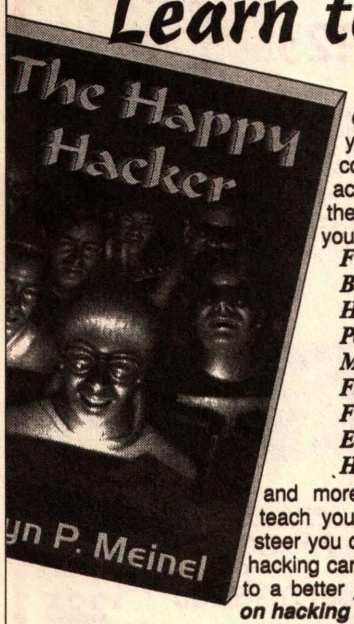

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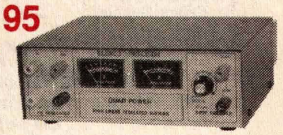

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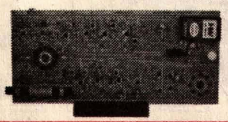

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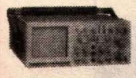

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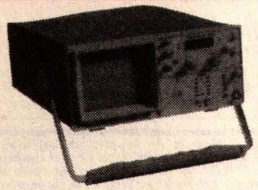

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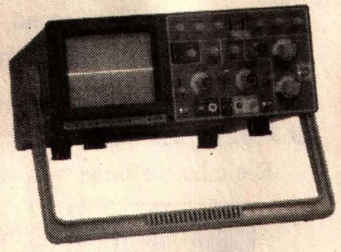

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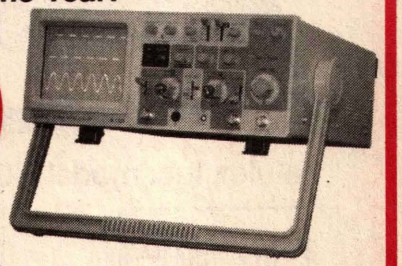

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- RS232 Output

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- RS232 Output

DS-203 20MHz **$695**

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- Delayed Sweep

S-1325 $325

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- TV Sync
- 1mV Sensitivity

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- **Pulse Generator**
  Digital waveforms with adjustable duty cycle

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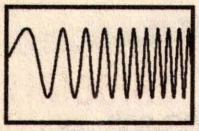
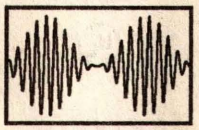
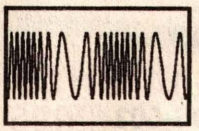
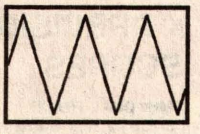
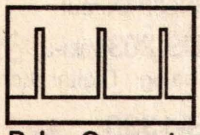

DC to 20 MHz linear and log sweeps

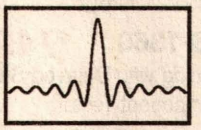

Int/Ext AM, SSB, Dualtone Gen.

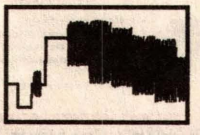

Int/Ext FM, PM, BPSK, Burst


Ramps, Triangles, Exponentials


Pulse Generator

Noise


Arbitrary Waveforms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Index guided. Threshold current 40 ma typical.

3 and 4mW, 1,300nm LASER DIODES, 5.6mm package, $15.00
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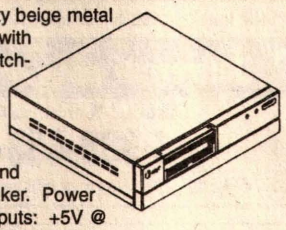

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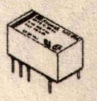

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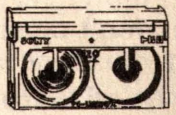

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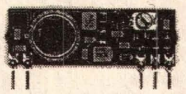

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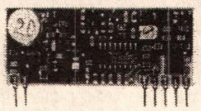

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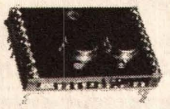

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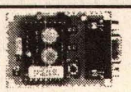

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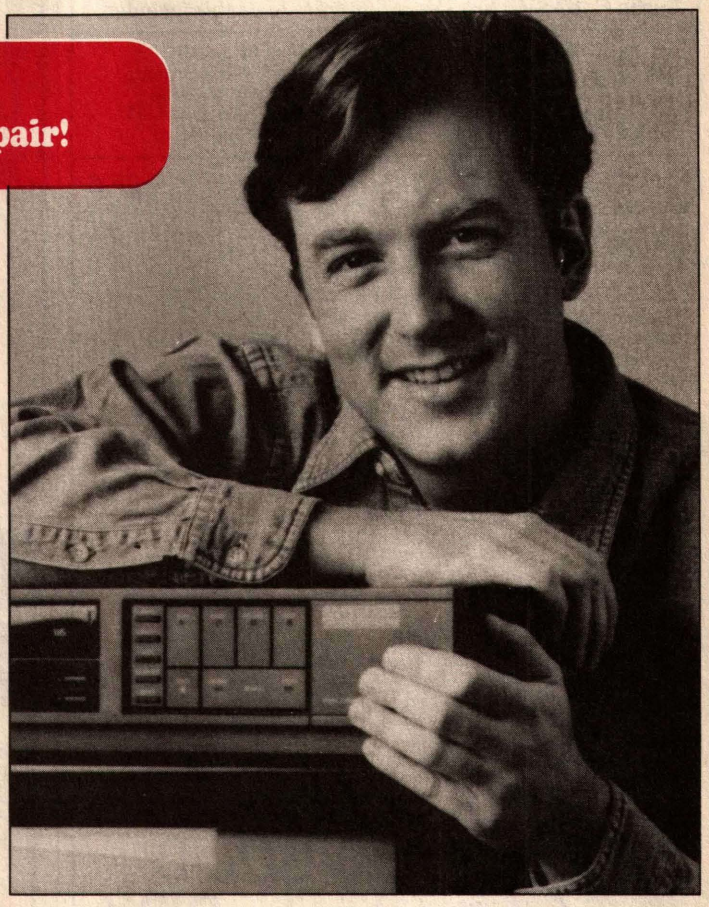

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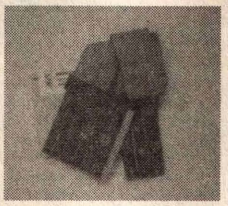

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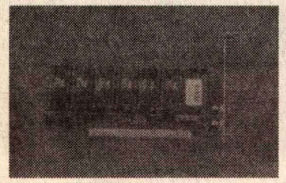

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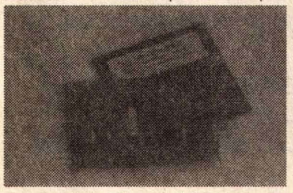

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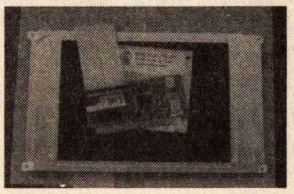

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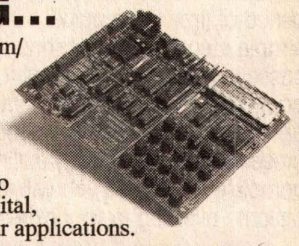

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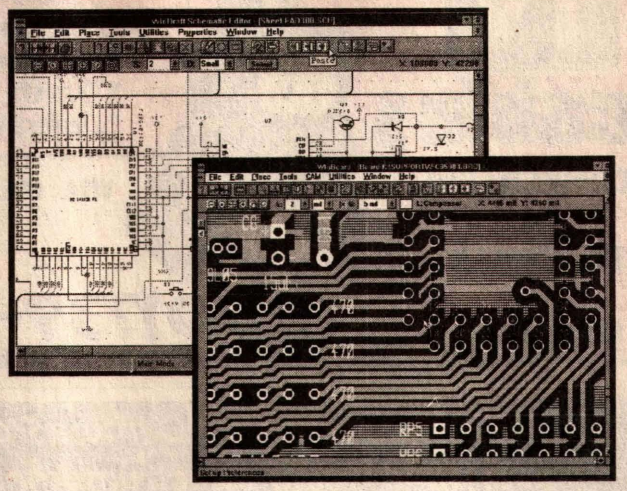

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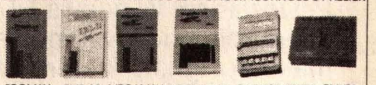

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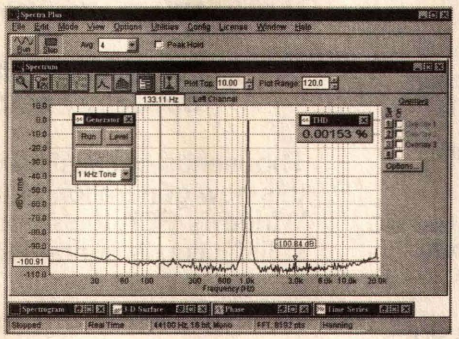

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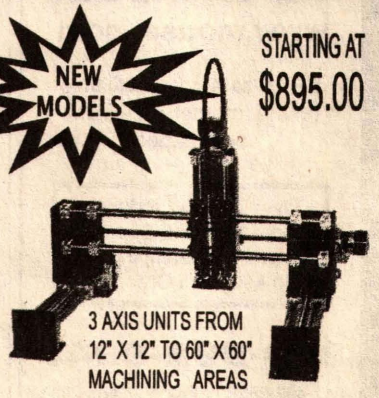

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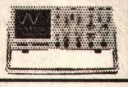

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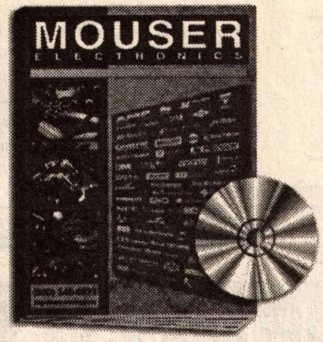

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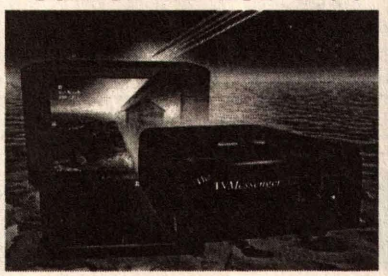

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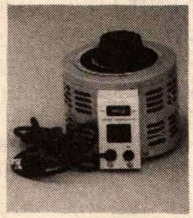

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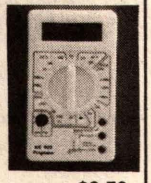

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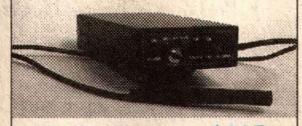

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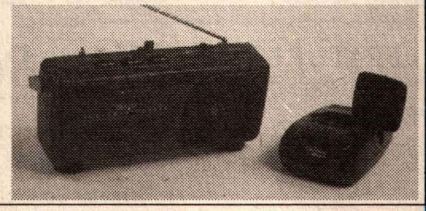

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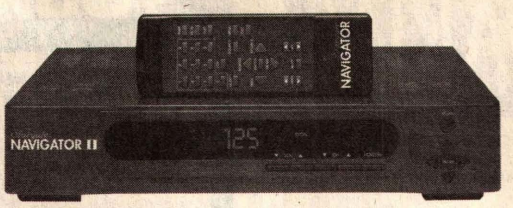

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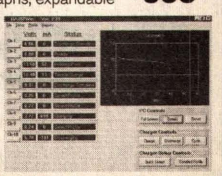

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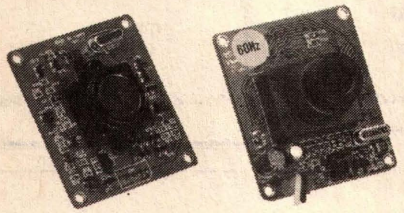

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277-040	MDT-40	58.50	56.50

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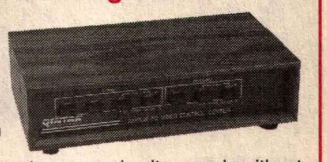

High quality video switching center gives you the flexibility to watch and/or record different sources simultaneously without the need to move complicated cables. Connect your VCR, CATV, satellite, video game, or home computer to two television sets. Gives you total control of your video system. 4 inputs, 2 outputs, all connections via "F" connectors. Pushbutton design. Amplified, broadband circuitry minimizes signal loss and crossover. Simulated wood grain cabinet. Net weight: 4 lbs.

#180-155 ..... **$42.90**(1-3) **$38.50**(4-UP)

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70 Series III Analog/Digital Multimeters

Part #	Model	Price
392-042	77-III	$174.75
392-026	70-III	96.50
392-032	73-III	125.95
392-036	75-III	154.80
392-038	26-III	213.50
392-046	79-III	193.80

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AUTHENTIC TECHNOLOGY
ESOTEC Cast Frame Woofers

Part #	Description	Price (1-3)	Price (4-UP)
297-210	8 Ohm, 15W-75, 5-1/4"	$127.50	$119.90
297-215	4 Ohm, 15W-75, 5-1/4"	127.50	119.90
297-230	8 Ohm, 17W-LQ, 6-1/2"	131.90	125.95
297-235	4 Ohm, 17W-LQ, 6-1/2"	131.90	125.95
297-240	8 Ohm, 20W-75, 7-1/2"	145.90	139.90
297-245	4 Ohm, 20W-75, 7-1/2"	145.90	139.90

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CIRCLE 262 ON FREE INFORMATION CARD

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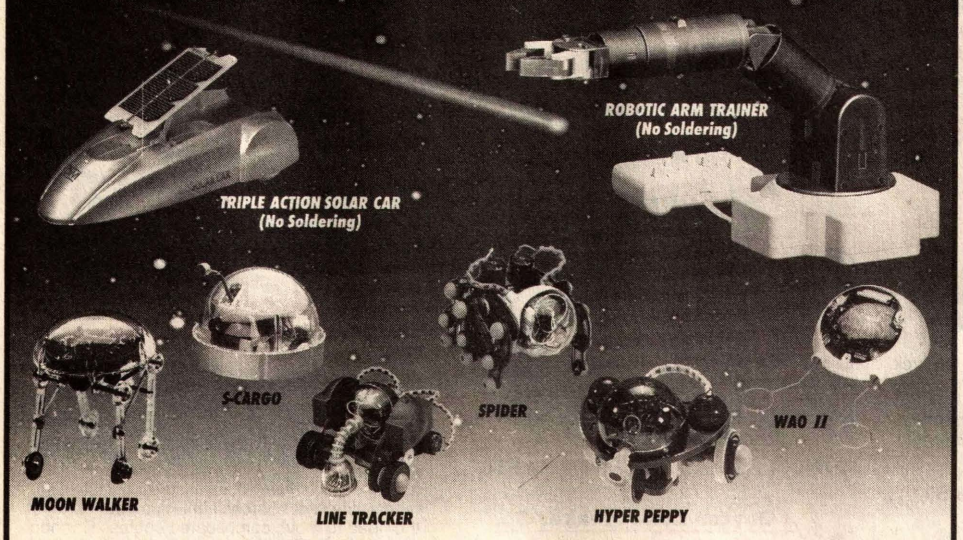

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HYPER PEPPY	OWI-969K	Sound / Touch Sensor	46 Pg. Book	24.95
MOON WALKER	OWI-989K	Solar Sensor	10 Pg. Book	34.95

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Whaddya Say To A Guy Who's Had The Same Job For 50 Years, Has Never Called In Sick Or Showed Up Late, Never Taken A Vacation Or A Holiday, Never Asked For A Raise Or Griped About His Bonus And, Believe It Or Not, Has No Plans For Retirement?

Thanks.

Remember - only you can prevent forest fires.

Ad Council

To learn more about life-saving techniques, call your Red Cross.

American Red Cross

EZ-EP DEVICE PROGRAMMER - $169.95

Check Web!! -- *www.m2l.com*

Fast - Programs 27C010 in 23 seconds

Portable - Connects to PC Parallel Port

Versatile - Programs 2716-080 plus EE and Flash (28F,29C) to 32 pins

Inexpensive - Best for less than $200

- Correct implementation of manufacturer algorithms for fast, reliable programming.
- Easy to use menu based software has binary editor, read, verify, copy, etc. Free updates via bbs or web page.
- Full over current detection on all device power supplies protects against bad chips and reverse insertion.
- Broad support for additional devices using adapters listed below.

Available Adapters

EP-PIC (16C5x,61,62x,71,84)	$49.95
EP-PIC64 (62-5,72-4)	$39.95
EP-PIC12 (12C50x)	$39.95
EP-PIC17 (17C4x)	$49.95
EP-51(8751,C51)	$39.95
EP-11E (68HC11 E/A)	$59.95
EP-11D (68HC711D3)	$39.95
EP-16 (16bit 40pin EPROMS)	$49.95
EP-Z8(Z86E02,3,4,6,7,8)	$39.95
EP-SEE2 (93x,24x,25x,85x)	$39.95
EP-750 (87C750,1,2)	$59.95
EP-PEEL(ICT22v10,18v8)	$59.95
EP-1051(89C1051,2051)	$39.95
EP-PLCC (PLCC EPROMs)	$49.95
EP-SOIC (SOIC EPROMs)	$49.95

Many Other Adapters Available

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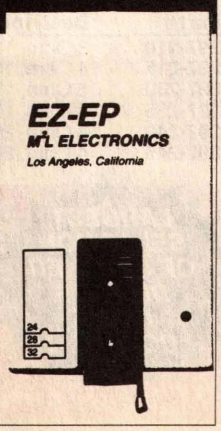
361 S Camino Del Rio Suite #119; Durango, CO 81301; CO orders add 7% sales tax.
http://www.m2l.com



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Pocket Multiprogrammer

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◆ Programs 8-bit and 16-bit EPROMs, EEPROMs, Zero Power RAMs, Flash, serial EEPROMs ◆ GAL, PALCE, ATF ◆ 87xxx, 89xxx, PIC12/16/17Cxx ◆ All DIL devices **without adaptor** ◆ **Lightning fast** parallel data transfer (e.g. 27C512 read/compare 2 sec!) ◆ Power supply independent due to **rechargeable battery** ◆ Uses PC printer port ◆ Hex, JEDEC, and binary file formats ◆ Hex and fusemap buffer editor ◆ Split & shuffle for 8-bit, 16-bit and 32-bit targets ◆ Runs under Win3.1, 95, 98 ◆ 'Remote control' by DDE scripts ◆ Designed for the future due to flexible pin driver technology - new devices will be added every month ◆ Device list, demo software and **lifetime free updates** from our website www.conitec.com!

GALEP-III Set with cable, battery, recharger **$389.00**

PLCC Adaptor for 8-bit EPROMs / 16-bit EPROMs / GALs .... **each $149.00**

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Price includes stand worth $25.00 one extra filter, and two tip cleaners.

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My Techs thought it would be a waste. I bought one anyway after a demo. My Techs then fought over it. Now we have three. It is the Best desoldering tool we have ever used.

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My personal guarantee to you is that after 90 days of ownership, if you are not convinced that you have made a wise decision for your business with the purchase of the SC-7000Z desoldering tools, your investment will be fully refunded with the return of the merchandise. Now you have no reason not to try it.

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- **Motor Output**——12W
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- **Control System**——Feed Back Zero Cross-over Type
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- Totally Self Contained diaphragm vacuum pump and AC motor for high vacuum suction or reversible hot air blow for SMD removal.
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- Unique patented long lasting filter cartridge design. Solder builds up on easily cleaned baffle, while air flows around the outside of baffle.
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General **Rubber Boot Included**

Display: 3-1/2 Digit LCD, 21mm Figure Height with Automatic Polarity
Overrange Indication: 3 Least Significant Digits Blank
Temperature for Guaranteed Accuracy: 23°C±5°C RH<75%
Temperature Ranges: Operating: 0°C to 40°C (32°F to 104°F) Storage: -10°C to 50°C (14°F to 122°F)
Power: 9V Alkaline or Carbon-Zinc Battery(NEDA1604)
Low Battery Indication: BAT on Left of LCD Display
Dimensions: 188mm long x 87mm wide x 33mm thick
Net Weight: 400g

$19.00 any qty

DC Voltage (DCV)

Range:	Resolution:	Accuracy:
200mV	100µV	
2000mV	1mV	±(1%rdg+2dgts)
20V	10mV	
200V	100mV	
1000V	1V	

Maximum Allowable Input: 1000V DC or Peak AC.

DC Current (DCA)

Range:	Resolution:	Accuracy:
200µA	100nA	
2000µA	1µA	±(1.2%rdg+2dgts)
20mA	10µA	
200mA	100µA	±(1.2%rdg+2dgts)
10A	10mA	

Overload Protection: mA Input. 2A/250V fuse.

Resistance (Ω)

Range:	Resolution:	Accuracy:
200Ω	100mΩ	
2000Ω	1Ω	
20KΩ	10Ω	±(1.2%rdg+2dgts)
200KΩ	100Ω	
2000KΩ	1KΩ	
20MΩ	10KΩ	±(2%rdg+10dgts)

Maximum Open Circuit Voltage: 2.8V

Diode Test
Measures forward voltage drop of a semiconductor junction in mV test current of 1.5mA Max.

ohFE Test
Measures transistor hFE.
Frequency Range: 45Hz-450Hz
Maximum Allowable Input: 750V rms
Response: Average Responding. Calibrated in rms of a Sine Wave.

AC Voltage (ACV)

Range:	Resolution:	Accuracy:
200V	100mV	±(1.2%rdg+10dgts)
750V	1V	

CAT NO	DESCRIPTION	PRICE
9300G	Rugged High Quality DMM with Rubber Boot	$19.00

Positive Photofabrication Kit
Make your own PCB's

Kit includes the basic items needed to fabricate pre-sensitized printed circuit boards (does not include artwork). Also included is a basic process guide to assist the user in the basics of exposing, developing and etching a PCB. All items fit conveniently in the plastic development tray, and a tight fitting lid is included for handy storage. Additional recommended supplies for fabricating PCB's are: exposure bulb, etchant tank, eye protection, art-work, paper towels.

Kit Includes

- 1 each 3"x5" pre-sensitized single sided PCB
- 1 each 4"x6" pre-sensitized single sided PCB
- 1 each 6"x6" pre-sensitized single sided PCB
- 1 each 500ml developer liquid
- 1 each 500ml ferric chloride etching liquid
- 2 each foam brushes
- 1 each plastic development tray
- 1 each rubber gloves
- 1 each instruction sheet

new!

CAT NO	DESCRIPTION	PRICE
416-K	Photofabrication Kit	**$27.95**

Positive Photo Resist Pre-Sensitized Printed Circuit Boards

These pre-sensitized printed circuit boards are ideal for small production runs. They provide high resolution and excellent line width control. High sensitive positive resist coated on 1oz. copper foil allows you to go direct from your computer plot or art work layout. No need to reverse art.

Single-Sided, 1oz. Copper Foil on Paper Phenolic Substrate

CAT NO	DESCRIPTION	PRICE EACH 1	10	50
PP101	100mm x 150mm/3.91" x 5.91"	$2.55	$1.90	$1.70
PP114	114mm x 165mm/4.6" x 6.6"	2.98	2.45	1.98
PP152	150mm x 250mm/5.91" x 9.84"	5.40	3.98	3.60
PP153	150mm x 300mm/5.91" x 11.81"	6.15	4.48	4.10
PP1212	305mm x 305mm/12" x 12"	12.78	10.65	8.52

Single-Sided, 1oz. Copper Foil on Fiberglass Substrate

CAT NO	DESCRIPTION	PRICE EACH 1	10	50
GS101	100mm x 150mm/3.91" x 5.91"	$ 3.90	$2.98	$2.60
GS114	114mm x 165mm/4.6" x 6.6"	4.80	3.49	3.20
GS152	150mm x 250mm/5.91" x 9.84"	8.69	5.98	5.78
GS153	150mm x 300mm/5.91" x 11.81"	10.20	7.20	6.80
GS1212	305mm x 305mm/12" x 12"	18.88	15.73	12.59

Double-Sided, 1oz. Copper Foil on Fiberglass Substrate

CAT NO	DESCRIPTION	PRICE EACH 1	10	50
GD101	100mm x 150mm/3.91" x 5.91"	$ 5.07	$3.68	$3.38
GD114	114mm x 165mm/4.6" x 6.6"	5.95	4.29	3.99
GD152	150mm x 250mm/5.91" x 9.84"	10.47	7.39	6.98
GD153	150mm x 300mm/5.91" x 11.81"	11.95	8.69	8.30
GD1212	305mm x 305mm/12" x 12"	22.09	18.35	14.68

Exposure System

Just place your presensitized board and artwork centered under the exposure fixture. Place the convenient acrylic sheet over the board and artwork to hold everything in place. Turn on light. Voila! Exposure takes about 5 minutes. Kit includes one fluorescent tube, stand and acrylic weight.

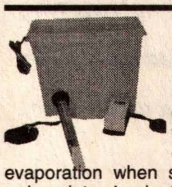
new!

Features

- Exposes boards in about 5 minutes!
- Convenient acrylic sheet to hold board in place during exposure (12.5" x 8.5")
- Fluorescent light fixture with plastic cover designed to aid in proper light refractions for even exposure

CAT NO	DESCRIPTION	PRICE
416-X	Fluorescent Exposure System	**$31.95**
416-B	Extra Replacement Fluorescent Tube	**16.95**

Etching Tank

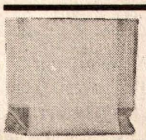


This handy etching system will handle PC boards up to 8" x 9", two at a time. Ideal for etching your PCB's! System includes an air pump for etchant agitation, a thermostatically controlled heater for keeping etchant at optimum temperature and a tank that holds 1.35 gallons of etchant. A tight fitting lid is also supplied to prevent evaporation when system is not being used. Typical etching time is reduced to 4 minutes on 1oz. copper board!

REDUCES ETCHING TIME!

CAT NO	DESCRIPTION	PRICE
12-700	Etch Tank System	$37.95

Developer



This product is used as the developer on our positive photo-resist printed circuit boards. Includes instructions. 50 gram package, mixes with water, makes 1 quart.

CAT NO	DESCRIPTION	PRICE EACH 1	10	25
POSDEV	Positive Developer	$ .95	$ .80	$ .50

Etching Chemicals/Ferric Chloride

A dry concentrate that mixes with water to make 1 pint of etchant, enough to etch 400 sq. inches of 1oz board.

CAT NO	DESCRIPTION	PRICE EACH 1	5
ER-3	Makes 1 pint	$3.50	$2.75

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CIRCLE 332 ON FREE INFORMATION CARD

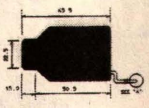
Color Weather Proof Bullet Camera

1/3" CCD with removeable rotation capable mounting bracket

new!

Specifications

Image Sensor:	Interline transfer CCD 1/3" format
Effective Pixel:	512(H)x492(V) pixels/NTSC 512(H)x582(V) pixels/PAL
Scanning System:	2 : 1 interlaced
Sync System:	Internal sync
Sync Pulse:	15.734KHz +1%(H)/15.625KHz +1%(H) 59.94Hz +1%(V)/ 50Hz +1%(V) Sub-Carrier 3.57 MHz +30ppm
Resolution:	400 TV lines (H)
S/N Ratio:	More than 46dB (typ)
Gamma Characteristics:	0.45
Min. Illumination:	1 LUX (F1.2 10 IRE)
Video Out:	Composite video signal : 1.0Vp-p
White Balance:	Auto white balance
Electronic Shutter:	1/60 - 1/100,000 SEC(N) 1/50 - 1/100,000 SEC (P)
Power Supply:	DC 12V + 10%
Power Consumption:	240mA (typ)
Lens:	4mm (78 or 92 degree) F : 2.0
Ambient Operating Temp:	-5 deg. C +40 Deg. C
Ambient Storage Temp:	-10 Deg. C+50 Deg. C RH 95% MAX
Dimension:	2 1/8" (L) x 1 1/4" (D)
Weight:	3 oz.



CAT NO	DESCRIPTION	PRICE EACH 1	5
WDB-5407S	Color Water Tight Bullet Camera	**$299.00**	**$269.00**

(water tight for outdoor use, not suitable for sustained underwater use)

CCD Bullet Cameras

Available with standard or pinhole lens. Virtually indestructible bullet shaped casing. This sleek B&W camera can be mounted on walls or ceilings along narrow corridors or virtually any location for virtually any surveillance application. 0.5 lux minimum illumination with 380 lines of resolution. Even includes a built-in electronic iris for automatic light compensation.

new!

Features

- Extremely low power consumption
- No blooming, no burning
- 0.5 LUX minimum illumination
- CCD area image sensor for long camera life
- Ultra small size allows for simple application and installation
- Built-in electronic auto iris for automatic light compensation
- Ultra compact camera

Specifications

Image Pick-Up Device:	1/3" CCD area sensor
No. of Pixels:	EIA = 512(H) x 492(V)
Pixel Pitch:	EIA = 9.6uM(H) x 7.5uM
Scanning System:	EIA=525 lines, 60 field/sec
Sync System:	Internal sync
H. Resolution:	430 TU line
V. Resolution:	400 TU line
Usable Illumination:	0.5 Lux F1.6
S/N Ratio:	More than 48dB
Gamma Characteristic:	0.45
Video Output:	1.0 - 1.1 up-p 75 Ohm
Electronic Shutter Time:	EIA=1/60 - 1/50,000 sec
Lens F No. Focal Length:	STD : 1.6 Open / 4.3mm(78 deg) Pinhole: 4.3 fixed/ 2.8mm(91.4 deg)
Power Consumption:	DC 9V (8-10V), 110mA
Operational Temp.:	-10 deg - +50 deg C RH95% max
Storage Temp:	-20 deg - +60 deg C RH95% max
Dimensions:	STD : 22mm(W) x 22mm(H) x 38mm(D) Pinhole: 22mm(W) x 22mm(H) x 30mm(D)
Weight:	35g max

CAT NO	DESCRIPTION	PRICE EACH 1	5
WDB-07S	Standard Lens Version	**$144.00**	**$129.00**
WDB-07P	Pinhole Lens Version	**144.00**	**129.00**
WDP-07S/water	Standard Lens Weather Proof	**169.00**	**152.00**

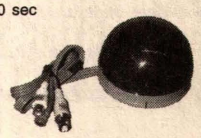
CCD Dome Camera with Audio

B&W DOME camera with integrated microphone. Ideal security system application. 12 VDC operation.

new!

Specifications

Image Device:	1/3" interline transfer CCD
Picture Elements:	EIA=542(H)x492(V)
Scanning System:	2:1 Interlace
Synchronization System:	Internal
Horizontal Resolution:	380 TV Lines
Sensitivity:	Under 0.3 LUX
Electronic Iris (linear):	EIA = 1/60~1/100,000 sec
Video Output:	1.0vp-p, 75 ohm
S/N Ratio:	More than 50dB
Power Supply:	12V DC (±20%)
Gamma:	r=1
Power Consumption:	110 mA max
Operating Temp.:	-10°C ~ +50° C
Operating Humidity:	RH 95% Max
Weight:	100g
Applied Lens:	3.6mm -92°, 4.3mm -78°
AI/EE/Flicker Less/Mirror Image:	Jump soldering selection
Audio Pick-up Sensitivity:	-60dB (0dB=1V/ubar)
Audio Frequency Range:	20 Hz ~ 20 kHz
Audio S/N Ratio:	More than 40dB
Audio Output Level:	1Vp-p/600 ohm
Dimensions:	87 x 55.5mm



CAT NO	DESCRIPTION	PRICE EACH 1	5
WDDB-6500	B&W Dome Camera	**$144.00**	**$129.00**

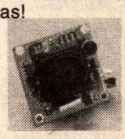
1/3" CCD Board Cameras

Available with **PINHOLE LENS** with **AUDIO**; **STANDARD LENS** with **AUDIO**; and **STANDARD LENS** with **INFRA-RED and AUDIO**. These are the world's smallest commercially available CCD board cameras!

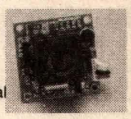
World's Smallest B&W Board Cameras

Specifications

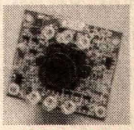
Image Pick-Up Device	1/3" CCD area Sensor
Picture Elements	EIA=512(H) x 492(V)
Pixel Pitch	EIA=9.6UM (H) x 7.5UM (V)
Scanning System	2 : 1 Interlace
Scanning Frequency	EIA=525 lines, 60 field/sec (II) 15.750 KHz x 60 HK
Resolution	430 Lines
Minimum Illumination	0.03 LUX
S/N Ratio	45DB
Lens Mounting	4.3mm standard, 5mm pinhole
Video Output	1.0 VP-P/750OHM composite signal
Power Requirement	8-12 VDC (9VDC standard)
Power Consumption	100mA
Operating Temperature	-20C -+ 70 C RH 95% Max
Storage Temperature	-40C -= 85 C RH 95% Max
Audio Pick-Up Sensitivity	-60 DB (0DB = 1B/UBAR. 1KNZ)
Audio Frequency Range	20 Hz to 20KHz
Audio S/N Ratio	More than 35DB
Audio Output Level	1VP-P/600 OHM



WDP-2000



WDS-2005



WDI-4000

Dimensions

WDP-2000	30mm (H) x 30mm (W)
WDS-2005	30mm (H) x 30mm (W)
WDI-4000	44mm (H) x 30mm (W)

CAT NO	DESCRIPTION	PRICE EACH 1	5
WDP-2000	1/3" B&W Pinhole Lens with Audio	**$89.00**	**$77.00**
WDS-2005	1/3" B&W Standard Lens with Audio	**89.00**	**77.00**
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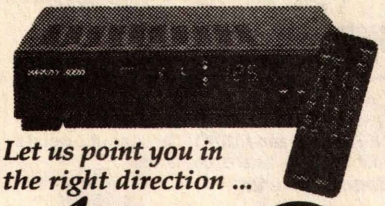

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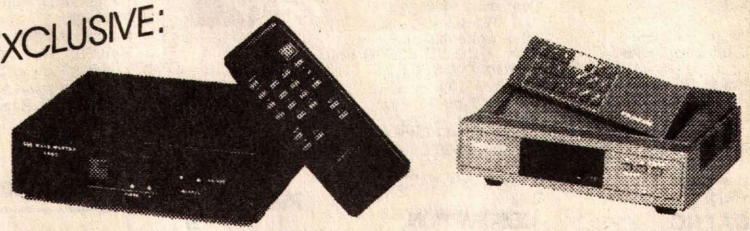

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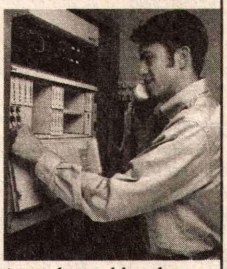

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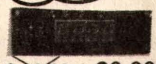


Kit $ ~~39.00~~ 20.00

This precision digital meter is a stand-alone voltmeter-ammeter or can interface with a computer! 4½ digit 0.55" LED display. Temperature compensated to 100 PPM/°C. Operating temperature range is 0°C to +70°C. Outputs include BCD date, Busy and strobe. Panel reading can be latched on hold.

Stereo Loudspeaker Protector TY-25 ▲

Kit: $ 16.75

Super fast acting relay protects speakers against destructive DC voltages. Can connect directly to a power amplifier or can use a separate power supply. Has a 3 second turn-on delay to avoid turn-on thumps.

Regulated DC Power Supply TR-503 ▲▲

Kit: $ 18.75

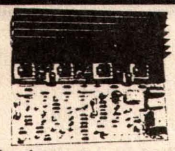
It is short circuit proof & has overload protection. Output voltage is variable over a range of 0-50 volts. Current limit trip is adjustable up to max of 3A. May use Mark V #002 transformer.

Fluorescent Light Driver TY-2 ▲ (1 lb.)

Kit:$ ~~14.75~~ 9.99

This unit drives 6-40 watts fluorescent light for portable and emergency use. Works from a 7.2 - 16 VDC battery. Includes a "Hi-Efficiency Switching Mode IC Driving Circuit" suitable for use with different lights.

120-250W Mosfet Power Mono Amplifier AF-2 (6 lbs.) ▲▲



Kit: $ ~~89.80~~ 76.33 Asmb.$ 114.80

Power Output: 250W into 4 ohms RMS(42VX2 6A transformer is used). 120W into 4 ohms RMS(33VX2 4A transformer is used). Frequency Response: 3Hz-22,000Hz. THD: <0.03%. Signal to Noise Ratio: 91dB. Sensitivity: 1V RMS at 47k. Load Impedance: 4 or 8 ohms. Power Requirement: ±46VDC 4A or ±60VDC 6A. May use Mark V model 012 Transformer. Suggested Capacitor 8,200uf 100V Model 020. Suggested Metal Cabinet LG-1925.

20 Color LED Audio Level Meter ▲

TY-13 (1 lb)

Kit:$ ~~23.50~~ 9.99

Use this dual LED display indicating meter with your stereo power amplifier to indicate instantaneous speaker power. Operating range is -30dB to +5dB and can be calibrated to operate with 1 to 200 W amplifiers. Not consume any amplifier power. A peak LED illuminates on overload!

300W High Power Mono Amplifier TA-3600 (5 lbs.) ▲▲▲

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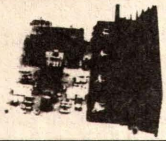
Kit:$ ~~89.00~~
Asmb.$ 115.00



Power Output: 300W into 8 ohms RMS. 540W music power into 8 ohms. Frequency Response: 10Hz-20KHz. THD: < 0.05%. Sensitivity: 1V RMS at 47K. Power Requirement: 60 to 75 VDC at 8A. May use Mark V Model 007 or 009 Transformer. Suggested Capacitor: 8,200uf 100V Model 020 Capacitor. Suggested Metal Cabinet LG-1925.

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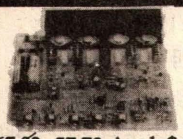
120W + 120W Pre & Main Stereo Amplifier TA-800MK2 (4 lbs.) ▲▲



Kit: $ ~~67.92~~ 57.73 Asmb.$ 86.95

Power Output: 120W into 4 ohms RMS. 72W into 8 ohms RMS. Frequency Response: 10 - 20 KHZ. THD: < 0.01%. Tone Control: Bass ±12dB, Mid ±8dB, Treble ±8dB. Sensitivity: Phono Input, 3mV into 47K. Line, 0.3V into 47K. Signal to Noise Ratio: 86dB. Power Requirement: 40V DC @ 6A. May use Mark V Model 001 or 008 Transformer. Suggested Metal Cabinet Model LG-1924.

80W + 80W Pure DC Stereo Main Power Amplifier TA-802 (4 lbs.) ▲▲

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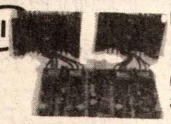
Kit: $ ~~49.94~~
Asmb.$ 69.94



Power Output: 80W per channel into 8 ohms. THD: < 0.05%. Frequency Response: DC to 200 KHZ, -0 dB, -3dB @ 1W. Power Requirement: 30V AC X 2 @ 6A. May use Mark V Model 001 or 008 Transformer. Suggested Capacitor 8,200uf 50V Model 017. Suggested Metal Cabinet LG-1924

60 + 60W Stereo Power Amp. ▲▲

SM-302 (11 lbs.)

Kit:$ ~~85.00~~ 76.50

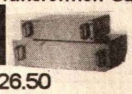
It provides 3 input jack pairs. One pair accept a high impedance microphone. The two remaining pairs are for high & low level input sources. Power Output: 60W per channel into 4 ohms RMS. 20Hz-20KHz. THD:<0.1%. Input Sensitivity :Mic /Guitar 10mV, Hi 380mV, Lo 640mV.Ready to plug in when assembled.

30W + 30W Pre & Main Stereo Amplifier TA-323A (1 lb.) ▲

29.25
Kit: $ ~~32.50~~ Asmb.$ 50.50

Power Output: 30W into 8 ohms RMS per channel. THD: < 0.1% from 100 HZ to 10 KHZ. Sensitivity: Phono 3mV @ 47K. Tuner, Tape 130mV @47K. Signal to Noise ratio: 80dB. Power Requirement: 22 to 36V AC, 3A. May use Mark V Model 002 Transformer. Suggested Cabinet LG-1684.

Metal Cabinets Aluminum Front Panel



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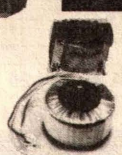

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# 003	40V x2	6A	32.00
# 008**	28V/30V x2	6A	42.00
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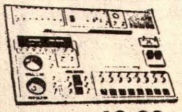

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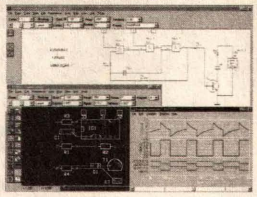

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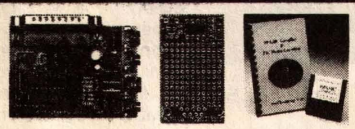

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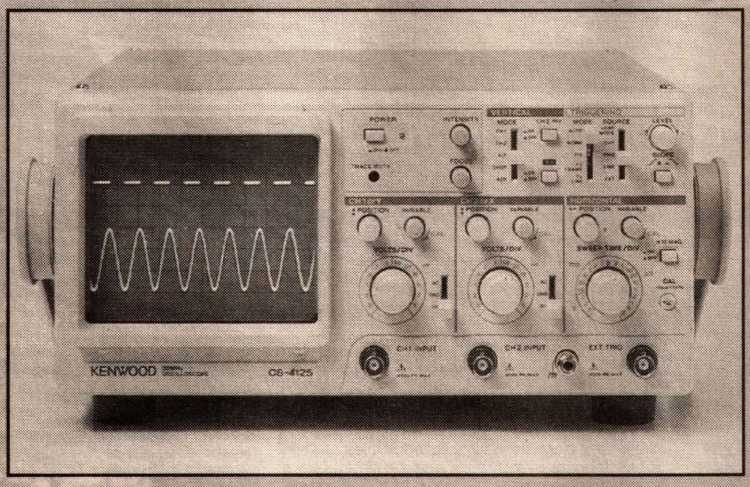

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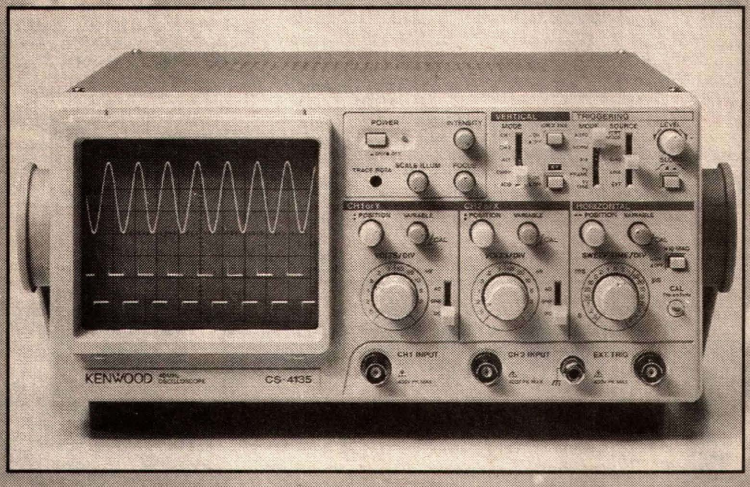

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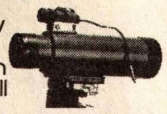

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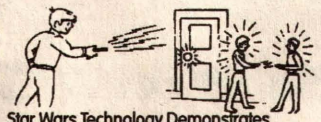

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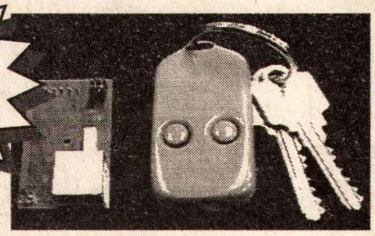

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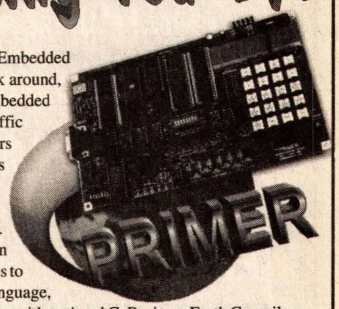

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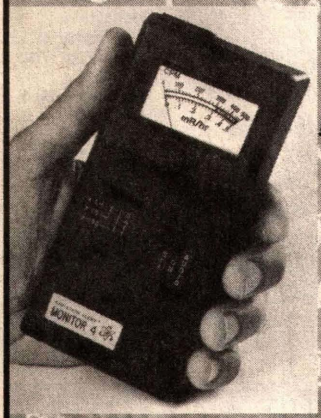

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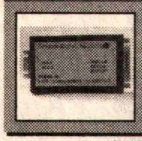

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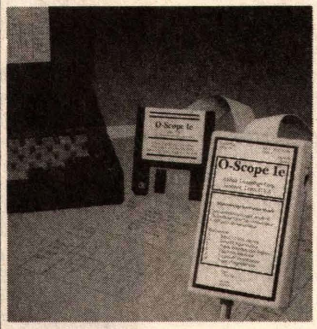

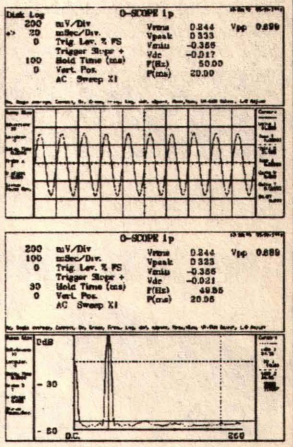

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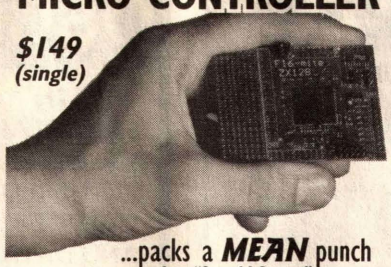

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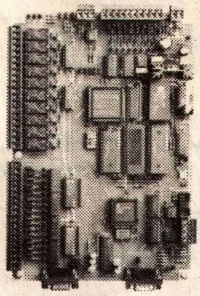

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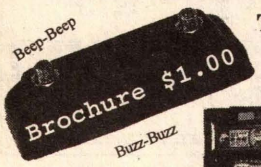

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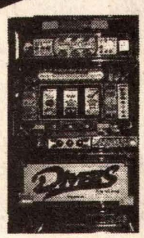

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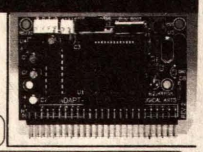

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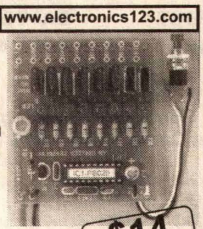

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We cannot bill for classified ads. **PAYMENT IN FULL MUST ACCOMPANY YOUR ORDER.** We do permit repeat ads or multiple ads in the same issue, but in all cases, full payment must accompany your order.

WHAT WE DO

The first word and company name of each ad are set in bold caps at no extra charge. No special positioning, centering, dots, extra space, etc. can be accommodated.

RATES

Our classified ad rate is $2.50 per word. Minimum charge is $37.50 per ad per insertion (15 words). Any words that you want set in bold are each .40 extra. Indicate bold words by underlining. Words normally written in all caps and accepted abbreviations are not charged anything additional. State abbreviations must be post office 2-letter abbreviations. A phone number is one word.

If you use a Box number you must include your permanent address and phone number for our files. ADS SUBMITTED WITHOUT THIS INFORMATION WILL NOT BE ACCEPTED.

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General Information: A copy of your ad must be in our hands by the 13th of the fourth month preceding the date of issue (i.e. Sept issue copy must be received by May 13th). When normal closing date falls on Saturday, Sunday or Holiday, issue closes on preceding work day. Send for the classified brochure.

DEADLINES

Ads not received by our closing date will run in the next issue. For example, ads received by November 13 will appear in the March issue that is on sale January 17. ELECTRONICS NOW is published monthly. No cancellations permitted after the closing date. No copy changes can be made after we have typeset your ad. NO REFUNDS, advertising credit only. No phone orders.

CONTENT

All classified advertising in ELECTRONICS NOW is limited to electronics items only. All ads are subject to the publishers' approval. WE RESERVE THE RIGHT TO REJECT OR EDIT ALL ADS.

AD RATES: $2.50 per word, Minimum $37.50

Send you ad payments to:
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190 -- Cable TV
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270 -- Computer Equipment Wanted
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17 - $42.50	18 - $45.00	19 - $ 47.50	20 - $50.00
21 - $52.50	22 - $55.00	23 - $57.50	24 - $60.00
25 - $ 62.50	26 - $65.00	27 - $67.50	28 - $70.00
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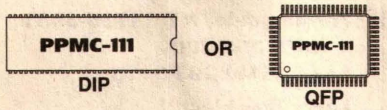

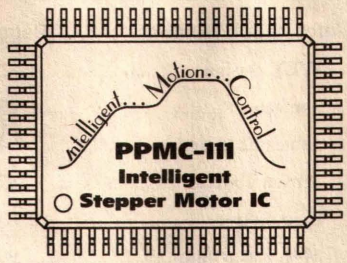

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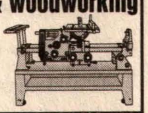

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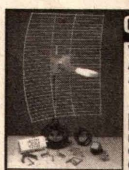

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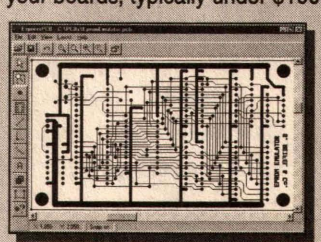

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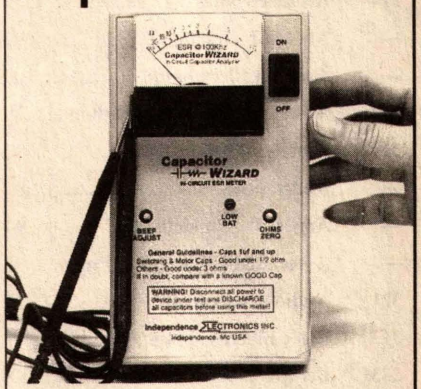

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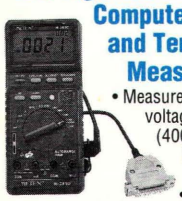
27115	M3800	$39.95	$35.95	$31.95

3 3/4-Digit Multimeter with Computer Interface and Temperature Measurement



- Measures AC/DC voltage: AC current (400mA to 20A), DC current (400mA to20A)
- Measures resistance (400Ω to 40MΩ), diodes and continuity
- Data hold switch
- Autoranging all scale settings
- Temperature measurement probe (-40°C to +1200°C)
- Measures transistor hfe, frequency and capacitance
- One-year warranty

Part No.	Product No.	Description	Price
117372	M3850D	3 3/4 digit	$119.95

4 1/2- Digit Multimeter with Computer Interface

- AC voltage: 200mV to 750V
- DC voltage: 200mV to 1000V
- 0.7" high digits
- Resistance: 200Ω to 20MΩ
- Capacitance: 2000pf to20µf
- Frequency: 20KHz
- Computer interface (RS232C) with software (5.25") and cable
- Data hold switch
- One-year warranty

Part No.	Product No.	Description	Price
106534	M4650CR	4 1/2 digit	$119.95

3 3/4-Digit Multimeter with Computer Interface and Dual Display

- Measures AC/DC voltage: AC current (400mA to 20A) DC current (400mA to 20A)
- Measures resistance (400Ω to 40MΩ)
- Autoranging all measurement settings
- True RMS
- Measures inductance capacitance, temp. (°C/°F), transistor hfe and frequency
- One-year warranty

Part No.	Product No.		Price
137461	M3860D	Special	$129.95

JAMECO® Tool Kits

12 Piece Tool Kit

- (2) Slotted screw-drivers: 1/8", 3/16"
- (2) Phillips screw-drivers: #0, #1
- (2) Nut drivers: 3/16", 1/4"
- (2) Torque screw-drivers: T-10, T-15
- Tweezers
- 3-claw parts holder
- 14-16 pin IC inserter/straightener
- 14-40 pin IC extractor
- Black vinyl carrying case
- Weight: 1.2 lbs.
- Size: 9.0"L x 5.8"W x 1.3"H

Part No.	Description	1-9	10-24
1189	Computer service kit	$14.95	$13.49

26 Piece Tool Kit

Excellent Kit for Electronics Repair and Maintenance!

- 2-in-1 carrying case has separate pocket to carry documents
- Weight: 7.0 lbs.
- Size: 16.0"L x 12.0"W x 4.0"H

Part No.	Description	1-4	5-9
135968	26 piece tool kit	Special	$59.95

51 Piece Tool Kit

Essential Kit for Electronic Machine Maintenance and Repair Jobs!

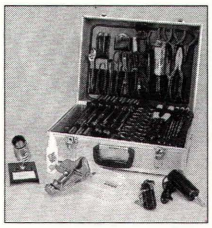
Case features removable pallets, a combination lock and a cushioned, black plastic handle.

- Weight: 10.4 lbs.
- Size: 12.5"L x 17.5"W x 3.5"H

Part No.	Description	Price
26681	51 piece tool kit	$99.95

66 Piece Tool Kit

Comprehensive Kit for Field Technicians and Engineers!



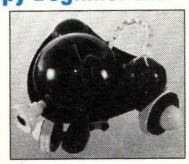
Aluminum case features removable pallets, surface type locks, a black plastic handle, side buckles and a strap.

- Weight: 15.5 lbs.
- Size: 18.0"L x 14.0"W x 6.0"H

Part No.	Description	Price
105646	66 piece tool kit	$179.95

OWI Kits

Hyper Peppy Beginner Kit



A fast and zippy robot who will reverse himself and resume a different course when he comes in contact with an obstacle or detects a loud sound.

Part No.	Description	1-4	5-9
140863	Beginers kit	$24.95	$22.49

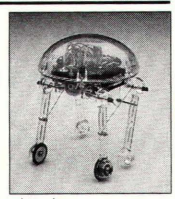
Soccer Robot Beginners Kit

Allows you to build this interactive robot with simple hand tools. Soccer robot has 6 operational kicking mechanisms. It runs forward, backward, turns left or right and executes 360 degree turns.

- Hardware for building the kit
- Control box and ball
- Weight: 1.1 lbs.
- Size: 12.0"L x 7.0"W x 3.5"H

Part No.	Description	1-4	5-9
140871	Soccer robot	$34.95	$31.95

Mecha Medusa Intermediate Kit



A walking robot that operates on the aid of sound sensor. Requiring only simple basic hand tools.

Part No.	Description	1-4	5-9
140847	Mecha-Medusa kit	$39.95	$35.95

Spider Advanced Kit

A robot that moves about avoiding obstacles by infrared ray sensing system.

Part No.	Description	1-4	5-9
140821	Spider advanced kit	$59.95	$53.95

Line Tracker Advanced Kit

A robot that follows a black line on white paper.

- Infrared sensor including infrared diode/ photodiode/ transistors/IC
- Hardware for building the kit
- 2 DC motors
- Size: 12.0"L x 7.0"W x 3.5"H
- Weight: 1.1 lbs.

Part No.	Description	1-4	5-9
140839	Line tracker	Special	$49.95

Macintosh® Products*

Quadra 610

Monitor Not Included

Includes keyboard, mouse, floppy drive, video port, SCSI port, printer port, modem port, stereo speaker port and MacOS pre-loaded.

- CPU/MHz: 040/24
- Memory: 16MB
- Upgradeable to 68MB
- Hard drive: 240MB
- 2X CD-ROM
- Ethernet: AAUI-15
- Slots: (1) NuBus/PDS

Part No.	Description	Price
154245	Quadra 610	$329.95

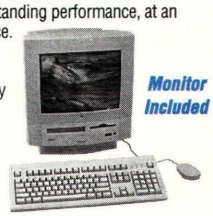
PowerBook 540c

Great for field applications or general administrative tasks. Includes floppy drive, SCSI port, printer port, ADB port, stereo speaker port and MacOS pre-loaded.

- CPU/MHz: 040/33
- Memory: 20MB
- Upgradeable to 36MB
- Hard drive: 320MB
- Ethernet: AAUI-15
- 19.6Kbps modem
- Color display: 9.5" active matrix LCD

Part No.	Description	Price
154296	PowerBook 540c	$699.95

Power Macintosh 5200



Monitor Included

Provides outstanding performance, at an affordable price. Includes keyboard, mouse, floppy drive, video port, SCSI port, printer port, modem port, stereo speaker port and MacOS pre-loaded.

- CPU/MHz: 601/75
- Memory: 16MB
- Upgradeable to 64MB
- Hard drive: 500MB
- 4X CD-ROM
- Slots: 1 each of LC. Comm, TV, Video I/O

Part No.	Description	Price
154350	Power Macintosh 520	$599.95

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Part No.	Description	Price
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154456	Color StyleWriter 1500	149.95
154499	LaserWriter 12/640 PS	939.95
154616	2X internal CD-ROM	69.95
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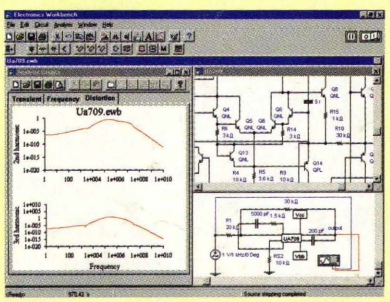

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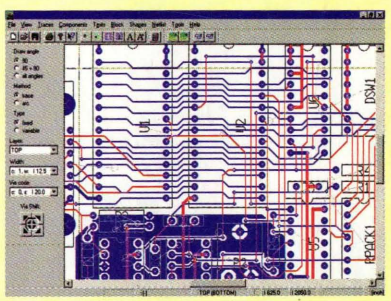
EWB Layout is a powerful board layout package for producing high-quality, multi-layer printed circuit boards. Offering tight integration with our schematic capture program, you can incorporate board layout and design and quickly bring well-designed boards to production.



$299 Version 5

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FOURIER	YES
NOISE	YES
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